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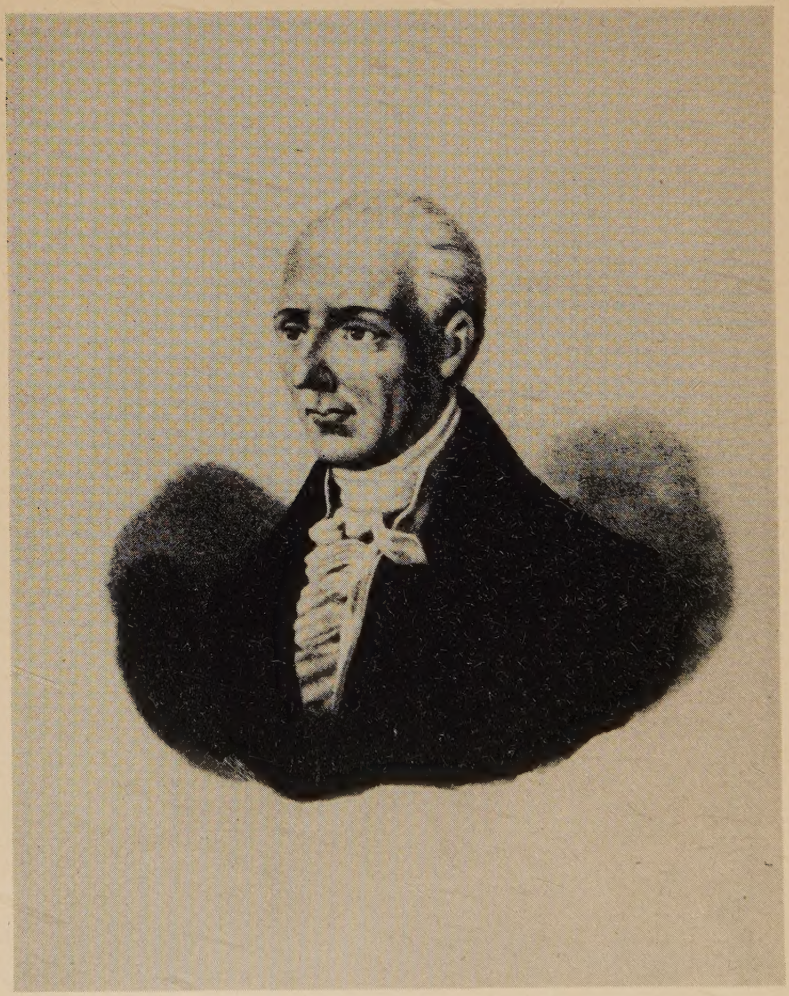

Iconoteca R. Istituto botanico di Padova

Giovanni Targioni Tozzetti

(1712-1783)

Phytopathological Classics

NUMBER 9

TRUE NATURE, CAUSES AND SAD EFFECTS OF THE RUST, THE BUNT, THE SMUT, AND OTHER MALADIES OF WHEAT, AND OF OATS IN THE FIELD

Part V of

ALIMURGIA

or

Means of Rendering Less Serious

The Dearths

Proposed

For the Relief of the Poor

By

GIOVANNI TARGIONI TOZZETTI

With

A biography and evaluation by Gabriele Goidànich

Translated from the Italian

by

Leo R. Tehon

In Acknowledgment To Professor G. Goidànich

This first English edition of the phytopathological writings of the 18th-century Giovanni Targioni Tozzetti owes much to Professor G. Goidànich who has brought the *Alimurgia* to present-day light through his modern printing in Italian of the original work. It is from his 1943 edition that the frontispiece portrait of Targioni and the identification of figures in the plate of drawings have been taken as also the foreword evaluating the place in phytopathological history of the *Alimurgia*. In addition Professor Goidànich has very graciously made available for inclusion with this English translation his biographical "Life and Works of Giovanni Targioni Tozzetti" which appeared originally in *Reale Accademia d'Italia*.

Editor

Life and Works of Giovanni Targioni Tozzetti [1]

Giovanni Targioni Tozzetti was born at Florence on September 11, 1712, of Leonardo Targioni, celebrated physician, and Cecilia Tozzetti, daughter of Girolamo, esteemed jurist.

He completed his higher studies at the University of Pisa, where he was awarded the doctorate upon presenting an erudite dissertation on the use of plants in medicine. For his exceptional cultural gifts and preparation in natural history, there was conferred on him, contemporaneously with the doctorate, the title Professor extraordinary.

Returning to Florence, he dedicated himself exclusively to the study of botany under the guidance of Pierantonio Micheli, also at that time universally famous, from whom he had had his first directions during the beginning of his university studies. He became the preferred scholar of the noted Micheli because of his great zeal in preparing an ample herbarium of the plants of Tuscany and the singular inclination he showed in the study of systematic and general botany; Micheli at once proposed him as a member of the Botanical Society of Florence, which had been founded a few years earlier.

In 1737 Micheli died and left Targioni Tozzetti his moral heir, entrusting to him library, herbarium, laboratory and all his manuscripts.

Giovanni Targioni Tozzetti considered it a sacred duty to complete the works which the Master had left incomplete and to make known publicly the greatness of his scientific personality. In this task Targioni came easily to nomination as titular of the Chair of Botany in the Florentine School and soon after as Director of the Botanical Garden, the same post occupied by Micheli up to his death.

To few men educated in the natural sciences has there been granted a career so rapid and brilliant and to very few has there been accorded a similar unanimous demonstration of esteem in the first years of their didactic and professional careers!

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[1] Goidànich, Gabriele. Reale Accademia d'Italia. Studi e Documenti 12. pp. vii-xi. 1943.

Placed in the post of the Master, he threw himself with all the energy of his young years and with the great erudition with which he was gifted into the determined task, and in 1748 he published, as his first trial, a catalog of the plants of the Botanical Garden instituted by Micheli; contemporaneously he performed an act that could have been brought about only by the spirit of a pure naturalist and sincere scholar in science: he employed all of his own capital and other borrowed capital for the acquisition from the heirs of all the scientific materials entrusted by the Master, which was threatened with becoming dispersed; the economic consequences of this deed pressed upon him through all his life, but he never complained.

Sometime after the publication of the first effort already mentioned and of the *Prodromo della Corografia e della Topografia fisica della Toscana* (1745)—in which are contained profound observations on the flora and agriculture of Tuscany, and copious information on the history of botany—other undertakings distracted him from the study of pure botany; at first the activity of the physician, in which he enjoyed as much fame as in that of botanist, so much indeed as to have been selected official physician to the Grand Ducal Court and the Exchequer, and Commisary of the Office of Health; on questions of medicine he published in short several memoirs, especially famous among which are those regarding the grafting of smallpox, of which he was a tenacious proponent, those on the epidemic fevers of certain years, on the salubrity and insalubrity of heights, his cases of apparent death, on asphyxia, on the dissection of cadavers, and on the poisonous qualities of vegetable substances that enter into the manufacture of bread. To his very interested activity is due also that in Florence the Faculty of Medicine had at its disposal a hospital for the professional preparation of students.

But the activity which most distracted him from the study of botany was that of the learned man who took the brunt of the burden possessed by the Prefect of the Magliabechian library in 1739. Targioni did not limit himself to the mechanical work of scheduling and systematizing into classes the exceptional bibliographic material which he had thus at his disposition, but profited by further instructing himself and, as was his custom, by leaving public testamonial of this instruction; indeed, five volumes were published relative to the correspondence maintained for thirty years by Magliabechi with the most illustrious scholars of the epoch, and others remained unedited for lack of the funds necessary to print them; the historical part of the *Alimurgia*, the examination of some projects of the sixteenth century to save Florence from the inunda-

tions of the Arno, the articles which he inserted in the first four volumes of the *Novelle Letterarie di Fierenze*, and the precise manuscripts for the literary history of Tuscany, are all fruits of his labors at the Magliabechiana.

Because of his demonstrated literary erudition, he was called to take part in the *Accademia della Crusca* and participated actively in the revision of the classical dictionary of the Italian language, rectifying a large number of definitions of scientific character that in the first edition had been somewhat neglected.

Fulfilling the fourth of his literary and artistic desires, the description of the monuments, ruins of old buildings, tombs, urns, furniture, ancient inscriptions discovered during the journeys he made throughout Tuscany and Rome and his customary comments on the history, laws, language, and culture of the populations which live in these places, were inserted by him in the eight published volumes, of the twelve projected, of the Accounts of those travels.

He was one of the founding associates of the *Colombaria*, Academy of antiquities, for which he wrote a memoire on the *Fiorino detto Suggello* (The Florin Called the Seal) and one on the cause of the increase in value of the *Fiorino d'Oro* (The Golden Florin); he took part also in the *Accademia degli Apatisti* (Academy of the Apathistas), of artistic-literary background.

The eight volumes ultimately recording his travels in Tuscany, a work largely conceived as to volume and thickness, illumines the great figure of Targioni as a naturalist in the broadest and truest sense of the word. In it Targioni revealed himself a profound connoisseur, as well of geological, mineralogical, geographical, meteorological, zoological, and agricultural questions as of botanical floristic problems. Aside from these, there are to be recorded the *Lettera sulle Farfalle efimere comparse nell'estate del 1741* (Letter on the ephemeral butterflies appearing in the summer of 1741) and the *Storia degli Aggrandimenti delle scienze fisiche ai tempi dell'Accademia del Cimento* (History of the aggrandizements of the physical sciences at the times of the Accademia del Cimento).

Finally, as least known, there appears recorded for us with certain particularity the agronomic activity of Giovanni Targioni Tozzetti. The great fame which he had acquired as cultivator of the other disciplines reviewed above tended to obscure that which he would have possessed also as an agronomist, perhaps because it seemed to posterity impossible that his versatility would push forward finally to invade a field so remote from the science in which he largely excelled, or because it appeared inadmissible that a pure scientist would confront with seriousness, worthy of being eulogized, questions

inherent in agriculture which as a science was then becoming delineated, but which commonly was considered the most humble and the least dignified of the sister sciences.

Targioni understood the necessity that agriculture should be removed from the empiricism which was then fully dominant and that the cultural technique of the field should be guided by principles springing from a plan of studies and experimentation purposively conducted. Therefore he was, with Montelatici, Lami, and Manetti, one of the founders of the *Accademia dei Georgofili*, to this day existing, for which he then wrote the *Ragionamenti sull'Agricoltura Italiana* (Rationalizations on Italian Agriculture): this volume contains above all the *Reflessioni sopra il metodo di studiare l'Agricoltura* (Reflections on a method of studying agriculture), in which he took a prospective view of a plan of research to which the *Georgofili* would devote themselves, becoming the promoters and also furnishing opportunity for the compilation of a *Compendio di Agricoltura* that would be "printed and, distributed over the Country, would serve as another subject of our Studies, directed to verify, to contradict, or to limit, or enlarge the rules or practices, with the duty of everyone separately to inform the Academy of the results of his observations, and experiences"; there follows, treating with richness of particulars, his clear dissertations on the principles of working the soil, on the culture of the artichokes, on the harvesting of mastic from the lentisk, on the cultural and commercial properties and characteristics of hard wheat, on the production, utilization and defects of cheese.

The *Alimurgia* then is a document of large and solid agronomic erudition; the first four chapters of the first volume all testify to the familiarity which Targioni had with the most varied problems of practical and theoretical agriculture and the fifth—which is reproduced in the present publication—says how profoundly we have been deceived as to the stature in the field of agrarian biology of this man, who, to study it, did not hesitate to introduce the most modern methods and criteria of scientific investigation, up to then reserved to medicine, or zoology, or pure botany.

The second volume of the *Alimurgia*, unfortunately not published, was wholly dedicated, as projected by the author, to agrarian questions, certain of them elaborately: "the entire physical theory" of bread making; the cataloging of all the parts of vegetables spontaneous and cultivated in Tuscany which can be made use of for food, condiment or in industry; the technique of the cultivation of the native and forestal plants as sweet roots; the conservation of wines and the use of substitutes in the forging of wine, beer, etc.; the use of substitutes for olive oil in nourishment, illumination and

industry; the utilization of the fibers of plants different from hemp and flax in the production of cloth, paper, cordage, etc.

This short illustration of the principal episodes in the life of Giovanni Targioni Tozzetti, and the cataloging of the works completed, initiated or projected by him,[2] may serve to make comprehensible why he may be considered one of those superior minds which Providence has generously dispensed to our Country, and which nourish through the centuries the beacon of civilization, the light of which has been received by all the people of the world.

He died in Florence on January 7, 1783, and was interred in Santa Croce among the Great.

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[2] To be seen for more particulars: Bibliografia botanica Targioniana ad. Targionio Tozzettio recensita agriculturae et usus plantarum quibusdam additis clariss, humaniss, botanicis Florentine congregatis a. D. MDCCCLXXIV Antonii Targ. Tozz. Med. D. et Johannis jun. jurisperiti filii superstites D. D. C. C.

The Alimurgia

Of Giovanni Targioni Tozzetti and its Importance in the History of Plant Pathology [1]

Gabriele Goidànich

The essay which is reproduced . . . in this publication constitutes the fifth chapter of the first volume—the only one published—of the work *Alimurgia*, which saw the light in Florence in the year 1767 through the printer Moücke.

The *Alimurgia* is a large folio volume of 376 pages compiled by Targioni Tozzetti "for the relief of the poor"; in it he proposed to give directions that would serve to render less serious the scarcities that periodically, and especially in the preceding years, had afflicted Tuscany and other regions of Italy. The first four chapters treat: the necessity of writing the *Alimurgia* and the advantage to be obtained by the reader; meteorological causes of the scarcities that afflict Tuscany; meteorological chronicle of Tuscany for the period of the last six centuries, especially in relation to agriculture; considerations on weathers favorable and contrary to the works and products of the soil.

The last chapter, the fifth, of 109 pages and one lithographed plate, was reserved entirely to the study of maladies of plants, especially of those that were cultivated and of agronomic importance, because the Florentine naturalist assumed that one of the principal causes of scarcities was the injuries that plants suffered as the effects of diseases, some of which, the rust, the rot, and the smut, decimated, when they did not reduce by half or destroy, production of the basic food commodities of the people: the cereals.

These pages, although limited to maladies of parasitic nature, constitute the first treatise on plant pathology, in the sense in which today we would speak of such publications. The clearness and the profundity with which questions of basic importance were imposed and confronted, the wisdom and the assurance with which the most difficult problems were solved, problems that tried the greatest students of the time and invited the activities of a large company of

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[1] Freely translated from the foreword, pp. XII-XXIV, of Goidànich's resurrection of the *Alimurgia* printed as Reale Accademia d'Italia. Studi e Documenti 12. 1943.

later scientists, cannot but astonish the modern reader as he recalls that this work was written in an epoch in which generally it was true that phytopathology was obscured in a cloud of hypotheses or indeed was dominated by superstitions that had prevailed from very early times.

The author of the *Alimurgia* deserves to be considered, therefore, the true precursor of modern phytopathology, which, affirming the concepts of the parasitism, pleomorphism and heteroecism of fungi, their linkage to determined conditions of the atmosphere and susceptibility to some methods, although in certain cases empirically determined, of prophylaxis and cure,—after the classical researches of the Tulasnes and the early works of De Bary—proceeded to the conquest of the difficult problems known for a thousand years and of the serious new problems that become intensified in agricultural production and are continually augmented by trade among peoples and traffic between continents.

Singular destiny of a work so marvelous!

The great mass of contemporaneous agriculturalists, for whom basically it was destined, accepted it without interest and in great part did not comprehend it. But a few of the more advanced agronomists and naturalists, among them Felice Fontana, were able to judge its value and significance, so that scientific disputes were kindled regarding the priority and veracity of the discoveries enunciated in the *Alimurgia*. These disputes, which could have served as tinder for new researches along the lines indicated by Targioni, quickly were extinguished by the fervid activity of the agronomists who occupied themselves with diseases of plants in the second half of the eighteenth century; these although having recourse in their investigations to the assistance of the microscope and making continuous references to both ancient and recent bibliographic sources, could not exceed the work of Targioni and returned to old, somewhat simplified ideas that found easy acceptance by the great public. Nor were the often repeated reminders of the son Ottaviano, Carradori, Gautieri, Philip Re and, much later, Gaetano Savi of value in withdrawing Targioni's work from the limbo of the forgotten, into which it had strangely fallen.

The echo of Targioni's phytopathological discoveries and the uproar that they provoked at the moment of publication did not die out entirely, however; they remained quite distinct at the beginning of the nineteenth century, influencing students who, in this epoch, attacked phytopathological questions with new spirit and more profound naturalistic preparation. The essence of the theories of the Florentine botanist—considered voluntarily or involuntarily anonymous—were exhausted of substance and in very large part appro-

priated with that freedom which was the expression of the little respect that even then, as formerly and especially in Mediaeval times, existed towards intellectual property.

Thus it was that Persoon, Prévost, DeCandolle, Banks and Léveillé "rediscovered" after many years facts and phenomena that our man had very clearly defined and maintained fathership of them undisputed up to our day. Who, for example, questions that the discoverer of the fungus nature of the smut of grains was Prévost, that the existence of the mycelium of the rusts was affirmed for the first time by Léveillé and Corda in 1839, that Persoon and DeCandolle were the first to establish that vegetable parasites were microscopic fungi analagous to molds of the type of *Botrytis*, *Aspergillus*, and *Penicillium*, that Banks (1805) first and much later De Bary (1853) proved that the germs of rust make use of the stomates as avenues of penetration into the host?

Not much different is the case for all the early and good part of the second half of the nineteenth century, very fertile in research on diseases of plants. The *Alimurgia* and Targioni Tozzetti as phytopathologist had disappeared from the memories of even the most erudite students and researchers, indeed even of those who were Italians. Tulasne and De Bary, who did not fail to adorn their classical experimental works with detailed historical information, ignored the merits of the now distant Florentine precursor. And very many others who turned their activities to the orbit of research vivified by these great men and followed in great part step by step their paths did not perceive the gap. Even Saccardo in his detailed *Storia della Botanica Italiana* forgot the mycological and phytopathological activities of Targioni and in his catalog of publications forgot the *Alimurgia*. And in the same case was Cattaneo, the erudite founder of the cryptogamic laboratory at Pavia, in his historical compendium of studies on the rust of wheat.

It is therefore greatly to the credit of Guiseppe Cuboni that—in one of the panoramic essays of which he was a master—he attributed the discovery of vegetable parasitism to the Italians Fontana and Targioni and rescued from oblivion the now very famous phrase of the *Alimurgia: "la ruggine è una intiera pianta parasitica piccolissima, la quale non nasce sennochè fra pelle e pelle del grano"* [the rust is an entire, very tiny, parasitic plant that grows nowhere except inside the skin of the wheat].

Cuboni's was not a *vox clamans in deserto;* it had its fruits; afterwards, at least among Italians, the name of Targioni re-acquired part of its deserved fame and there have been none of our contemporaneous treatises on vegetable pathology that have not reported more or less exactly the above-recorded phrase. However, as far as I

can ascertain, none has taken care to review the other profound concepts that were connected with it.

Contrary to what has been the case in Italy, contemporaneous foreign literature has continued to ignore completely the work of our naturalist. Whoever will take care to review, as I have done, the texts on plant pathology written in the various languages of major or minor weight will search in vain in the faultless historical treatises that they contain for even a simple citation of Targioni. There are seen elevated to the role of the precursors and honored as founders of phytopathological thought students of much later date than our man, who, as scientific figures, however respectable, are by some cubits inferior to Giovanni Targioni Tozzetti.

But, finally, what greatly astonishes us is that works expressly dedicated to the history of phytopathology possess the same defect. This is true of that old but nevertheless pleasing work of Sorauer's in the first edition of the *Handbuch für Pflanzenkrankheiten* and of that very detailed work of Braun's in the sixth edition of the same manual; it is true finally of Whetzel's *An Outline of the History of Plant Pathology*, which enjoys universal esteem as a complete and perfect work.

In the fifth chapter of the *Alimurgia* is brought together almost all the phytopathological work of Giovanni Targioni Tozzetti.

In great part it is devoted, as it appears, to the study and description in great particularization of the diseases of parasitic origin of cereal plants (wheat, barley, maize, sorghum, oats, rye; rusts, rots, smuts, rye ergot especially); with a smaller profusion of particulars a large number of diseases of other garden plants are then treated (bean, pea, vetch, kidney bean, fennel, beet, plum, grape), of ornamentals (rose, aquilegia, linden, holm oak, *Paliurus, Cercis*), of wild plants or those cultivated for scientific purposes in the Royal Garden of Simples or in the Garden for the Repose of the Aged in Florence (*Potentilla*, *Euphorbia*, *Polygonum*, *Plantago*, *Ranunculus*, *Senecio*, *Sonchus*, *Hypericum*, *Cynanchium*, *Lonicera*, etc.).

The very first affirmation of basic phytopathological importance contained in the *Alimurgia* is that all maladies now cataloged are due to the parasitism of other microscopic vegetable organisms. It is true that before the appearance of the *Alimurgia* significance had already been attached to similar microorganisms in the etiology of some maladies: more than half a century earlier Tournefort in his work *Observations on the Maladies of Plants* considered moldiness a cause of damage among crowded cultivated plants; a little

later Alberghetti had, very obscurely in truth, related molds to the rust of wheat; Hales in his famous *Vegetable Staticks* thought that the first cause of the "*mal bianco*" was an arrest of transpiration through occlusion of the stomatal apertures operated by the water that fills the leaves (an idea that he generalized for many other maladies and that was very largely believed), always having as a constant epiphenomenon the appearance of a white mold that took possession at that point where the lymph, in consequence of the arrestment of transpiration, became fermented and corrupted. A few years before the appearance of the *Alimurgia*, Aymen attributed the smut of wheat to the mustiness of the seed and sought to demonstrate this by making experiments.

As may be seen, rather vague hypotheses, the fruits of pure conjecture, are treated; these, however, always mark a clear progress from the concepts that predominated from biblical times; all the pathological phenomena of vegetables were in effect attributed by the great mass of the profane and the technical to supernatural intervention or to sidereal-meteorological processes, or, at the most, to pedological causes.

The one man who, more than all others, approached the ideas of Targioni was one of his contemporaries, Felice Fontana, the noted physiologist of Pisa, honored in Italian natural science. In his little treatise, which became—a thing unusual for publications of that era—immediately famous and which appropriately saw the light in the same year as the *Alimurgia*, Fontana maintained that the rust of wheat is a parasitic plant, although not in an absolute sense, as are Cuscuta, Orobanche and mistletoe, being capable of attacking healthy hosts only in an attenuated form, its development being conditioned by the pre-existence of a pathological state in the plant. Fontana says that these parasitic organisms take possession of the leaves and stalks of the wheat after there have been produced in these organs, following the extravasation of lymph from the vessels and subsequently to fermentation, ulcerations through which the humor issues to the outside; in such ulcerations the plantlets of rust find the environment necessary for their development, and it is by the above-mentioned extravasated humor that they are nourished. In other words, Fontana returned to the ideas of Hales, which, however, he developed with greater profundity and especially with a higher sense of veracity.

The position taken by Targioni in the affirmation of vegetable parasitism is, in contrast, very clear; the analogy between phanerogamic parasites and microorganisms of the rust type is in itself complete; the latter are capable of taking possession of vegetables in perfectly healthy condition, provided that environmental conditions,

especially temperature and humidity, render possible the growth of their germs, which the air contains in great quantity.

This concept alone, so clearly expressed, was enough to make worthy of admiration the phytopathological work of Targioni. But there is more: considering the possible mode of penetration of the rust infection, he had not the least doubt that it takes place through the stomatal aperture. This is an idea to which, denying or admitting it with more or less marked reservations, a great number of students, from Banks to DeCandolle, Prévost, Léveillé, and Bonorden, to cite only the greater, have been obliged continually to return; and the controversy was not terminated until after the publication of the works of Tulasne and De Bary exactly a century after the *Alimurgia*. Furthermore, Targioni had the intuition that a road of penetration of fungus infection would lie through the stigma: "a seed of imperceptible smallness, scattered by the air, and implanted by chance in the apex of the embryo of the wheat, where stand the two tubes formed in the fashion of a feather, and through which the volatile fertilizing substance of the Apexes penetrates into the embryo, there it being implanted, grows, and enchasing the radical fibers of its base, precisely in the little apertures of the canals destined to carry food to the embryo of the wheat, it takes as property, and usurps, so to speak, this food, and causes the embryo to die of hunger, fattening and increasing at its expense." This singular infective process, which Targioni attributes to bunt, was discovered a hundred years later for the "loose" smuts.

Also, the existence of mycelium was affirmed in an unequivocal manner in the *Alimurgia;* the rust, it was said, "which [the bottom of the sorus] on the outside is woven of certain very short and delicate rootlike hairs, and they enchase themselves within the arterial vessels that carry the nutritive humor to the wheat plant, and there they form themselves. These hairs steal and suck up for themselves the nutriment prepared and destined for the grain. . ." The mycelium, which had already been described by Malphghi and Marsili for the higher fungi, was held by some microscopists—as said above—to have been discovered much later. Targioni recognized and recorded it for several other parasites besides the rusts.

The formation of rust pustules is described in the *Alimurgia* with astonishing precision: the parasite penetrates through the stomates, multiplies in the surrounding parenchyma, and then "immediately that the increase of volume forces the cuticle of the wheat outward, and makes it swell, and finally crack in a very delicate spangle" . . . "it is manifest to our eye in the form of an orange powder that pours out from the interior of the opened sore on the stem, or on the leaf,

of the wheat, adheres to all bodies that it touches, and then is carried away easily by the wind or washed by the rain."

From this passage and many others it appears that Targioni had no doubt that the principal vector of the germs of fungi would be, as it is in fact, the wind.

Another observation and affirmation worth regarding as important is that the yellow and the black rust of wheat are different stages of one and the same disease. Targioni could not know that later discussions of this proposition would be numerous and that scientists such as DeCandolle, Corda and Léveillé, basing their arguments especially on the diverse morphological structures of the organisms existing in the black and yellow pustules, a fact that escaped Targioni, would maintain that they were entirely different parasites; the argument, although it was waged as if it were interminable polemically, was however terminated with De Bary.

. . . . . .

Among the numerous parasites that are described in the *Alimurgia* it is possible to identify with certainty the following species: *Puccinia graminis*, *Phragmidium subcorticum*, *Puccinia Asparagi*, *Puccinia Pruni-spinosae*, *Uromyces Fabae*, *Cronartium asclepiadeum*, *Tilletia Tritici*, *Puccinia coronifera*, *Puccinia Caricis*, *Uromyces striatus*, *Uromyces Trifolii*, *Phragmidium Potentillae*, *Puccinia Tanaceti*, *Darluca filum*, *Puccinia Balsamitae*, *Puccinia Polygoni-amphibii*, *Melampsora Euphorbiae-dulcis*, *Melampsora Helioscopiae*, *Melampsora Gelmi*, *Puccinia Menthae*, *Phyllosticta Ruborum*, *Colletotrichum Lindemuthianum*, *Cystopus Tragopogoni*, *Oidium erysiphoides*, *Ustilago Zeae*, *Ustilago carbo*, *Sphacelotheca Hydropiperis*, *Claviceps purpurea*, *Plasmopara pigmaea*, *Erysiphe Cichoriacearum*, *Peronospora Viciae*, *Melampsora salicis*.

A goodly number of other parasites are not identifiable with precision, considering the scarcity of distinctive characters reported: *Puccinia simplex*, *Puccinia Lolii*, *Puccinia Tanaceti*, *Septoria Helianthi*, *Helminthosporium turcicum*, *Puccinia purpurea*, *Clasterosporium carpophilum*, *Cercospora Beticola*, *Peronospora alta*.

Another group, also rather numerous, is identifiable only by hypothetical means, depending altogether on the characters of the alterations provoked on the hosts, the morphological indications being too few: *Puccinia Agrostidis*, *Puccinia glumarum*, *Puccinia coronata*, *Uromyces Trigonellae*, *Uromyces scutellatus*, *Phyllosticta Bizzozzeriana*, *Ascochyta Podagrariae*, *Phyllos-*

ticta Epimedii, Septoria Sii, Phyllosticta Cornicola, Septoria Tiliae, Coniosporium Arundinis, Epicoccum purpurascens, Phyllosticta Acetosae, Cercospora Plantaginis, Phyllosticta Jasmini, Ascochyta Siliquastri, Septoria Siliquastri, Phyllosticta Siliquastri, Stigmatea Mespili, Septoria Melissae, Rumularia Ballotae, Cercospora plumbaginea, Cercospora rosaecola, Phyllosticta rosarum, Cercospora cistinearum, Ascochyta Fagopiri, Ovularia Bistortae, Septoria Polygonorum, Sphaerella Hieracii, Phyllosticta Ehrhartii, Ascochyta cornicola, Phyllosticta ilicina, Gnomonia Quercus-ilicis, Oidium Ruborum.

This more than considerable complexity of micromycetes Targioni subdivides into three categories or families:

the first comprises the intercutaneous parasites "that grow and vegetate only beneath the cuticle, and within the cortical and medulary substance of divers plants of large size"; under the generic name of "*ruggini*" he unites the rusts properly speaking—Puccinia, Cronartium, Uromyces, Phragmidium, Melampsora—, *Tilletia Tritici*, and fungi morphologically and pathologically quite different from these: Sphaeropsidales (*Phyllosticta, Septoria*), Melanconiales (*Colletotrichum*), Peronosporales (*Cystopus*); Targioni, however, noted well the difference existing between these last and true rusts: "There remain certain others, of which I am not truly assured whether they ought to be ascribed to this same family, or whether they constitute two others different and distinct. Certainly I see in them the globular fruits . . . and I see the radical tufts incarnate in the substance of other plants [the mycelium]; but the vegetation or, so to speak, ramification is diversified notably, except that not being dependent on having it, I have seen it also not well mature and perfected." The grouping together of these different microorganisms is then made only tentatively; they are remanded "to the more decisive observations that others will be able to make upon them";

the second comprises those semi-intercutaneous parasites that have, so to speak, "their roots within the skin of the leaves"; in this category he placed the trichomes differentiated in the erinoses, which he thought to be fructifications of vegetable microorganisms, and some species of Peronospora;

the third, finally, unites the cutaneous parasites that "borne as they are on the surface of the plant, lop down and distend themselves upon it, attaching their branches by means of radical fibers, as does the Ivy. . ."; to this he ascribes divers species of *Peronospora* and *Oidium*.

The parasites of the first family, the "rusts," are distinguished as 13 kinds, almost all identifiable:

I	kind of rust:	*Puccinia graminis*
II	" " "	*Phragmidium subcorticum*
III	" " "	*Uromyces Fabae* (teleutosporic stage)
IV	" " "	*Puccinia graminis* (?), *Puccinia Lolii* (?)
V	" " "	*Puccinia Pruni-spinosae*
VI	" " "	*Uromyces Fabae* (uredosporic stage)
VII	" " "	*Cronartium Asclepiadeum*
VIII	" " "	Collective kind comprising *Tilletia Tritici* and divers species of *Puccinia*, *Uromyces*, *Phragmidium*, *Melampsora*
IX	" " "	*Puccinia Menthae*
X	" " "	Not identifiable
XI	" " "	*Phyllosticta ruborum*, *Phyllosticta Epimedii* (?), *Septoria Sii*
XII	" " "	*Colletotrichum Lindemunthianum*
XIII	" " "	*Cystopus Tragopogoni*

As is apparent, the classification established by Targioni is anything but exact. It, however, demonstrates that the Florentine naturalist had an absolute perception of the richness of forms of the microscopic world that he was exploring, and of the necessity of giving these forms an orderly arrangement, preceding in this the founders of systematic mycology in the early years of the Nineteenth Century: Persoon, Link, DeCandolle, Corda. And the distinctive characters to which he turned for characterizing the families and the kinds, although not exactly attributed and evaluated, had nevertheless real taxonomic significance and later would be largely utilized.

To judge fully the phytopathological work of Giovanni Targioni Tozzetti it is necessary to remember that he was not exclusively a parasitologist; that is to say, he did not become so much imbued by his discovery as to maintain that only microorganisms could cause diseases of plants. Quite otherwise: upon reading the first part of the *Alimurgia*, one may see how Targioni attributes notable importance also to environmental-meteorological factors in the provocation of pathological conditions of vegetables: "The principal foments of vegetation are heat and humidity, distributed in doses adjusted and well balanced against each other. One of these, if it exceeds in quantity or duration, disturbs the system of vegetation and, if it does not prove prejudicial to the expansion of branches and production of foliage, ruins the flowering and allegation of fruits. Thus too strong or too long drying through lack of rains and

fogs or dews and heat too great and strong for the season make plants dry and atrophied, so that they cannot support the flowers and embryos, and no good comes of them: on the contrary, too much humidity from the rain causes a kind of dropsy in plants, with juices so enervated and inert that at the most they are suitable only to increase, to multiply the leaves, etc." "Fatal above all are frosts that, after hot days, fall in serene evenings at the close of the day, with the moon out and without wind, when one least expects them, and in one moment burn the tender shoots and flowers, etc."

Furthermore, the particular significance that these same environmental conditions have in the determination of parasitic infections did not escape Targioni. "Seeds of the rust of imperceptible minuteness, floating through the air, insinuate themselves into certain vesicles situated in rows all over the stems of the wheat, and *at a definite degree of heat and of humidity of the air, begin to grow, enchase*, etc."

When Giovanni Targioni Tozzetti's *Alimurgia* is given its proper value, the history of phytopathology and vegetable parasitism assumes in the first phase of its development an aspect quite different from that which has been attributed to it up to now.

The lineaments of phytopathological thought across the years are full of generalities fixed by historians of the science in the following manner: the ideas possessed by the Georgian Greeks and Latins, of fear of the maladies of plants, ideas that in great part were of biblical origin, dominated all the Middle Ages and went unchallenged up to 1700, an era in which is noted an evident awakening of phytopathological thought. This awakening was crystallized in larger degree, especially after gardeners and farmers became involved, in the establishing and describing of pathological phenomena and in the early attempts, although indeed in part empirical, to find practical methods of control other than those, already demonstrated as fallacious, that were used and advised by the ancients.

With this was connected an intense "taxonomic" activity, aimed at a classification and denomination of diseases of plants following the scheme of human pathology; medicine reigned at that time uncontested as queen of the sciences and there was not a good naturalist, whether first a botanist, zoologist, or physicist, who was not also a physician. The base of this classification was purely symptomatological; no etiological criterion discovered itself to the minds of the numerous phytopathologists, or, if such criteria arose, they were apparently limited to or concerned with questions of secondary importance and left no trace in the thought of contemporaries. All the 1700's from the appearance of the work of Tournefort (1705) to that of the manuals of Forsyth (1791), Plenk (1794), Schreger (1795),

Ritter von Ehrenfels (1795), and Re (1807) passed with the same tenor.

One must pass—according to the opinions of the historians of phytopathology—to the beginning of the nineteenth century before, with the intervention of the great names of plant physiology, the fundamental problems of plant pathology are revealed and the road is prepared for the great experimental affirmations of the early nineteenth century and the succeeding period.

Anyone who will review all the phytopathological production of the eighteenth century will agree with me in affirming that in this century the dawn of phytopathological thought did not occur, although there were established some of the most solid bases on which is mounted the magnificent edifice of knowledge which we possess today—after the productive labor, doubly secular, of scientists of every country—in the field of plant diseases.

To Tournefort (1705) goes the credit of having given some significance although indeed indirectly, to molds in the damaging of crowded plants, to Hales (1731) of having recognized *Oidium* in the etiology of the "*mal bianco*" of hops, to Aymen (1763) of having thought that mustiness was a possible cause of the smuts of cereals, and to Adanson (1763) of having accepted and made public the ideas of these naturalists.

In the next period Tillet, in 1755, inaugurating the experimental system of phytopathology, demonstrated unequivocally the infective character of the powder of the smut, calling attention at the time to a contemporary method of combatting this disaster that was substantially what is in use today. The experiences of Tillet, which became very famous, were repeated by Ginanni and Arduino, by Humes, and later by Tessier, who almost unanimously confirmed the efficacy of the procedure of "medication" of the seed proposed by Tillet.

In 1767, then, as if to crown this blossoming of new ideas, there appeared the studies of the contemporaries Felice Fontana and Giovanni Targioni Tozzetti, both of whom declared the vegetable nature of the rust microorganism, of which they gave precise descriptions and morphological illustrations, while one of them, Targioni, fixed in the *Alimurgia*, with all the assurance that he had from complete microscopic observations—elaborated by his very fervent mind, and with the authority that he enjoyed as an exact and scrupulous naturalist—, the basic concepts of phytopathological science which we have reviewed above.

Can phytopathological thought be said, perhaps, to have been in a primordial condition in an epoch in which it was textually stated thus: "This writer, by means of diligent and repeated microscopical observations, has made it clear that the rust, which in this memorable year 1766 caused such a calamity in Italy, is a very tiny parasitic

plantlet not discernible except with the aid of good microscopes, the seeds of which, imperceptibly minute, float through the air, insinuate themselves within certain vesicles situated in rows everywhere on the stems of the wheat and, at a definite degree of heat and humidity of the air, grow there, enchase the absorbing little mouths of a certain plancentiform radical expansion of theirs in the arterial canals of the wheat (especially if the wheat plants are young and tender), inosculate them perfectly, and appropriate them as their own, in much the same way as the chokeweed appropriates the roots of legumes and the mistletoe the branches of trees on which they grow. The tufts of the rust, by sucking up and converting into proper food the liquid that ought to rise to the spike of the wheat, quickly enlarge, unfold many jointed little stems, and become loaded with dactyl-shaped fruits to the extent that by their bulk they crack the cuticle of the wheat, beneath which they have developed, and become manifest to the naked eye in the form of an orange-colored dust. Then the damage has already been done to the wheat, because the rust, in the guise of a leech, has sucked up and consumed, by means of such arteries as it has appropriated, the food that ought to rise to the spike to nurture and, indeed, to ripen the seed"? (*Alimurgia*, Chapter IV, pp. 239–240.)

Towards the middle of the eighteenth century there was, then, a company of students who should be recognized and honored as the founders of phytopathological science. Their works have not had the fame that they merit among students of plant diseases, either contemporaneously or in succeeding generations, since in great part they grew out of agronomic studies and were not provided with that equipment of naturalistic ideas which is indispensable for assimilating advanceguard concepts such as those expressed by earlier men. But it cannot be denied that such works exercised, although relatively indirectly (and better considered elsewhere), a notable influence on the development of phytopathological research in the succeeding period, when the guidance of studies on diseases of plants returned to the hands of naturalists, especially those trained in plant physiology, and were even a principal cause of the rapid evolution of phytopathological thought in that period.

Among this company of precursors and founders of phytopathological science the figure of Giovanni Targioni Tozzetti looms large and his work, synthesis and crowning achievement of the wonderful scientific activity of the epoch, collected in that part of the *Alimurgia* which we shall reproduce . . . in the pages that follow, is of a scope powerful in size and especially in profundity of view, with the classical stamp of the Italian genius.

ALIMURGIA

O SIA

MODO DI RENDER MENO GRAVI

LE CARESTIE

PROPOSTO

PER SOLLIEVO DE' POVERI

ED UMILMENTE PRESENTATO

ALL' ALTEZZA REALE DEL SERENISSIMO

PIETRO LEOPOLDO

PRINCIPE REALE D' UNGHERIA E DI BOEMIA

ARCIDUCA D' AUSTRIA

GRAN DUCA DI TOSCANA

ec. ec. ec.

DAL DOTTOR

GIOVANNI TARGIONI TOZZETTI.

Tomo Primo.

IN FIRENZE, MDCCLXVII. PER IL MOÜCKE.

Con licenza de' Superiori.

A ſpeſe di Giuſeppe Bouchard Libraio in Mercato Nuovo.

True Nature, Causes and Sad Effects of the Rust, the Bunt, the Smut, and Other Maladies of Wheat, and of Oats in the Field

THE terrible scourge of the Rust, to which the Fields of the greater part of the Temperate Zone of the Northern Hemisphere have been subjected from time to time, even from distant Ages, merits the most serious attention of Naturalists, for the purpose of investigating the causes of it, and proposing, if it should be possible, some remedy, or preservation. I have endeavored in a few tag-ends of time, to make some observations, which, if nothing else, may serve as a stimulus to Talent more happy than mine to make clear the nature, and theory of the Rust of Wheat, and of other Vegetables cultivated for the service of Mankind.

Various have been the Years infamous for like misfortune; but not one so fatal can be pointed out as the one just passed, 1766, in which the Rust was universal over the whole of Italy, and in all the different levels and exposures of its territory. The Sowing in the Autumn of the year 1765 truly was not very good, because the Seeds of the Wheat, and of the Oats, after their ripening, suffered much from dampness in the Field, in the Stacks and on the Threshing Floor, and they were badly cured, many of them even sprouting in the Spikes, and in the Stacks likewise, and owing to almost continuous Rains and Coolness, on the Plains of Florence it was hardly possible to accomplish the Threshing at the beginning of August, but in the cooler and more Mountainous Territories, it was necessary to defer it to a part of September. Certainly never during the whole of the Summer, and not even during the Dogdays, was there a day that absolutely appeared to be a Summer day, making one sweat, and become restless by chance; but always there were either excessive and cool Rains, or cool and stormy Winds of the West, and North-east Winds, or Mists and Clouds, so that the Late-season Oats blossomed badly, and for the greater part they were clouded, and disappeared in Aftergrass, and there was a very scarce Harvest of Grapes, of Autumnal and Winter Fruit, of Olives, and Chestnuts. The first day which truly could be called a Summer day was September 13, a day exceedingly fortunate, and always memorable in

Tuscany, on which the Royal Persons of our Most Gentle Sovereigns Peter Leopold, and Maria Luisa, for the first time made Florence happy with their so much desired Presence. From this day the Season went forward most beautifully and warmly, until St. Michael's Day and October was made up of gentle Rains and good and serene days; therefore the Countrymen strove to prepare, as best they could, the Land for Seeding. The Summer, so cool, and damp, had not allowed the Land to be broken and worked, and therefore there had not been the required rotting, and the roots and the Seeds of the Herbs, had not been burned; and neither in the Lands near the Sea, nor in the Mountains was it possible to make the usual Burnings, and Small Furnaces. Therefore it is necessary to consider the Autumnal Seeding of 1765 very unhappy, and one from which an abundant Harvest ought not to be expected. November, and December went forward truly not wretchedly, but the Wheat appeared thinly scattered in the Fields, small, and of a washed-out color. It appeared hopeful that the succeeding Winter would correct the defects of the Seeding, because it did not lack Cold, Snows, and Ice. Certainly the Year 1766 appeared on the scene with very acute Cold, which was maintained during all of January and for some days in February, the degrees being recorded by Sig. Doctor Luca Martini, with a Thermometer from Mons. de Reaumur, situated on the Terrace of the House on the Plazza de Pitti, where he resides at present. In the morning then at the hour eight the Thermometer was at zero, or mark of the Ice on the days January 6, 26, and 28; at half a degree below Freezing on the day January 29, and on February 11, 12, and 24; at one degree precisely below zero on the days January 1, 20, 27, and 31, and on February 1; at one degree and a half below zero on the days January 10, 11, 24, 25, and 30; at two below on the days January 7, 12, 21, 22, and 23; at two degrees and a half below zero on the days 14, 15, 16, 17, and 18 of the same month; at three degrees likewise below zero on the day [January] 8, and it sank as low as five degrees on the one day [January] 13. There were then 29 very cold days, of the 55, that passed between the days January 1 and February 24, and some very cold Wintry days occurred throughout the entire time until the day March 2 (on which occurred the opening of Spring), but much less severe than those noted above. For the Thermometer was above the zero, or mark of the Ice, half a degree on the days January 19 and February 10; one degree the day February 25; one degree and a half the days January 5 and 25 and February 2 and 26; two degrees the day February 9; two and a half the days 4, 8, and 23 of the same month; three degrees the days January 2, 3, and 4 and February 7 and 22; three degrees and a half the days February 5, 6, and 13; four degrees

the days 20, 21, and 27 of the same; four and one quarter the day 28; four and a half the days February 16 and March 1; finally five degrees the days February 14 and 15 and March 2. The Thermometer indeed jumped on February 17 to six degrees, on the 19th to seven, and on the 18th to eight, but this period of the opening of Spring was irregular, and extraordinary, because the Thermometer then declined until the day March 3, on which, in one jump, it ascended to seven degrees and a half. During this long and severe Winter period, the condition of the Barometer, according to the very exact observations of Sig. Pietro Grifoni, communicated kindly by Sig. Doctor Carlo Alfonso Guadagni, was thus.

At Thumbs 27, and lines 4 and a half the day February 5.
At Th. 27, 1. 5 the day February 6.
At Th. 27, 1. 7 the day February 4.
At Th. 27, 1. 7 and a half the days January 10 and March 3.
At Th. 27, 1. 8 the days January 3 and February 8 and 9.
At Th. 27, 1. 9 and a half the days January 5, 6, 9, and 11.
At Th. 27, 1. 10 the days January 4 and February 3 and 10.
At Th. 27, 1. 11 the days January 2, 7, and 8 and February 7, 17, and 19.
At Th. 28, the days January 24, February 15, 16, 18, 20, 21, and 25, and March 2.
At Th. 28, and half a line, the days February 2, 22, and 26.
At Th. 28 and 1. 1 the days January 12 and 25, February 11, 27, and 28, and March 1.
At Th. 28, and 1. 1 and half the days January 1, 20, and 21 and February 24.
At Th. 28, and 1. 2 the days January 13, 14, 26, 27, and 28.
At Th. 28, and 1. 2 and a half the days January 16 and 19 and February 3.
At Th. 28, and 1. 3 the days January 15, 17, 18, 22, and 23 and February 12, 13, and 14.
At Th. 28, and 1. 3 and a half the days January 29 and February 1.
At Th. 28, 1. 4 the one day January 31.
At Th. 28, and 1. 4 and a half the one day January 30.

The qualities then of the Weathers were the following.

Clear the days January 2, from the 13th to the 26th, and from the 28th to 31st, February 11, and from the 20th to the 25th, and March 1.

Variable the days January 11 and 27 and February 1, 3, and 10.

Overcast the days January 1, 3, 9, and 20, February 14, 15, and 16, 26, 27, and 28, and March 2.

Rain the days January 2, 4, and 19, and in February from the 4th to the 9th, the 12th, and from the 17th to the 19th.

Snow heavy in Florence the day January 10.

Frost occurred during a part of the others, and moreover the Mills could not grind flour from January 12th to the 16th.

The great Cold of this very severe Winter, burned and killed the Pot Herbs of Kitchen Gardens, many Flowering Plants and Simples in the Gardens, and damaged severely the Artichokes, and the Olive Trees. Among others, it scorched the Wheat, and the Beans, and held them back much more than they should have been, except that it proved to have the good effect of making them bushy, which in other years only happens after dry Colds.

At the opening of Spring, that is at the beginning of March, the Fields appeared burned, and the Wheat and the Oats appeared miserable, as if scorched, sparse, and wire-thin. This Spring was in the main very beautiful, and such that for many years there had not been one like it, therefore there appeared to be a revival, and quickly the suffering of the raw Winter was put out of tune. The First part of it, or the Childhood of the Year, was a period of 29 days, that is from the day March 3, until the day April 20, in which for the first time the Thermometer at the hour 8 in the morning ascended to 11 degrees. The temperature of the Air in all this course of days was not always maintained constantly above six degrees, for on the days March 24 and 29 it descended to five degrees and a half, on the days 10 and 15 to five degrees, and on the day 25 even to three degrees and a half. Despite this irregularity, it could be said that the First part of the Spring of 1766 was very good, and favorable to the Growth of Plants, for the Thermometer, stood at six degrees on the days March 13, 14, 16, 17, 22, and 26; at six degrees and three quarters on April 11; at seven degrees on March 4 and 6; at seven degrees and one quarter on April 14; at seven degrees and a half on the days March 3, 8, 9, 12, 18, 19, and 21; at eight degrees on the days March 11, 20, 23, 28, and 30 and April 1 and 13; at eight degrees and a half on March 6 and April 2; at eight degrees and three quarters on April 4, 10, and 12; at nine degrees on March 5, 27, and 31 and April 3; at nine degrees and a half on April 14; at nine degrees and three quarters on April 16; at ten degrees on April 5, 7, 8, 15, and 18; at ten degrees and three quarters on April 19; at eleven degrees on the 6th and 17th of the same month, and finally at twelve degrees on the day April 20.

The Barometer kept within the following measures.

At Thumbs 27, and lines 5 on the day March 22.
At Th. 27, and 1. 6 the days March 4, 14, and 28.

At Th. 27, and 1. 7 the day March 23.
At Th. 27, and 1. 7 and a half the day March 21.
At Th. 27, and 1. 8 the days April 11 and 20.
At Th. 27, and 1. 9 the days March 5 and 27 and April 18.
At Th. 27, and 1. 9 and one quarter the day April 9.
At Th. 27, and 1. 9 and a half the days March 29 and April 8, 10, 16 and 19.
At Th. 27, and 1. 10 the days March 19, 25, and 26, April 3 and 5.
At Th. 27, and 1. 11 the days March 18, 30, and 31, April 1, 12, 13, 14 and 15.
At Th. 27, and 1. 11 and three quarters the days April 2 and 11.
At Th. 28, the day March 7.
At Th. 28, and one half a line the days March 6 and 17.
At Th. 28, and one line the days March 10, 12 and 13, and April 6.
At Th. 28, and 1. 1 and a half the days March 8, 9, and 16.
At Th. 28, and 1. 2 the days March 11 and 15.
At Th. 28, and 1. 2 and a half the days March 14 and April 7.
Clear were the days March 5 to 16, 19, 22, 24 and 25, and April 1, 2, 4, 5, 6, 7, and 12.
Variable March 17, 18, 20, 27, 28 and 29, April 8, 9, 10, 16 and 20.
Overcast April 17.
Rain March 3, 4, 21, 23, 26, and 30, and April 11, 13, 15, 18 and 19.

In such a sweet Season then the Fields prospered a little, and all the Plants put forth buds in lively fashion, and began a vigorous Growth, which consoled the Countrymen. Quite short, and not so happy was the second section of the Spring, from April 21 to May 6, that is, only 16 days. During this time the Thermometer at one hour after mid day was at twelve degrees, on the days April 23 and 24; at twelve degrees and one quarter on April 25; at thirteen degrees on April 21, 22, and 27; at thirteen degrees and one quarter on April 28; at fourteen degrees on April 20, 29, and 30, and the first four days of May; at fourteen degrees and three quarters on April 26; at fifteen degrees on the 5th day of this month; and at 16 degrees and three quarters on the 6th day.

The Barometer stood on these days.

At Thumbs 27, and lines 6 and a half on April 26.
At Th. 27, and 1. 7 and a half on April 25 and 27.
At Th. 27, and 1. 8 on April 21.
At Th. 27, and 1. 9 on April 28.
At Th. 27, and 1. 11 on April 30, and May 1.
At Th. 27, and 1. 11 and a half on May 3.
At Th. 28, on May 4 and 5.

At Th. 28, and 1. 2 and a half on May 6.

Clear were the days May 2, 3, 4, and 6.

Variable the days April 29 and 30 and May 5.

Rain from April 21 to 28, and the first of May.

Under such a constitution of the atmosphere, predominantly humid, the Plants grew very flaccid and tender, and did not have time for good consolidation, and their Transpiration did not proceed with proper felicity. The Summer Heat made itself felt soon, that is, the day May 7, and continued to the day September 11, on which the Thermometer at an hour after mid day, was discovered to have fallen to 18 degrees; although on the day following it rose to 19, and then always until the day [September] 27, on which a tempestuous Wind arose, it remained high between 18 degrees and a half, and 26. As the opening of Summer this year was so much anticipated, so the first half of it precisely, that is until the day July 17, which is [a period] of 72 continuous days, was very irregular, and more like Spring than Summer. For the Thermometer was at eleven degrees on the day May 15; at twelve degrees and three quarters on June 1; at thirteen degrees and a half on May 17; at fourteen degrees and a half on May 20; at fifteen degrees on May 13 and 16; at fifteen degrees and a half on June 1; at sixteen degrees on June 4, 5, and 6; at sixteen degrees and a half on the 2d day of this month; at sixteen degrees and three quarters on May 10; at seventeen degrees on May 21 and June 3; at seventeen degrees and three quarters on May 23; at 18 degrees on May 11, 12, 22, 24, 25, 26, 27, and 29, June 8, 9, 15, and 16, and July 4 and 7; which total 29 days of Spring temperature, of the 72 in the first half of Summer. One finds the Thermometer likewise at 18 degrees on the day September 11; but it rose to eighteen degrees and a half on May 20, June 10 and 21, and September 22; to nineteen degrees on May 7, 8, and 9, June 13, 17, 19, 20, 25, 26 and 27, July 3, 9, and 13, and September 12, 14, 17, 20, 25, and 26; to nineteen degrees and a half on June 14 and 24; to nineteen degrees and three quarters on September 24; to twenty degrees on June 18, 28, and 29, July 5, 10, 11, 15, 16, 18, and 29, and September 7, 10, 13, 18, 23, and 27; to twenty degrees and a half on the day September 20; to twenty-one degrees on the days June 11, 12, and 21, July 1, 2, 6, 14, 22, 24, 25, and 26, August 16, 17, 18, 19, and 21, and September 8, 15, 16, and 19; to twenty-one degrees and one quarter the day September 9; to twenty-one degrees and a half the days June 23, July 8 and 27, August 22, and September 2; to twenty-two degrees on June 30, July 12, 17, 19, and 20, August 14, 28, and 30, and September 6; to twenty-two degrees and a half on the day August 23; to twenty-two degrees and three quarters

on the day August 24; to twenty-three degrees on the days June 22 and 23, August 11, 27, 29, and 31, and September 1, 3, and 4; to twenty-three degrees and a half on the days July 21 and 28, and September 5; to twenty-four degrees on July 30, August 5, 15, 25, and 26; to twenty-four degrees and a half on August 7 and 12; to twenty-five degrees on July 31, and August 2, 3, 4, 6, 8, 9, and 10; finally to twenty-six degrees on the day August 13. From this abridgement of the degrees of Temperature, it is easily understood, that in the 72 days of the last half of Summer, the Temperature of the Atmosphere must have been very great, and not only very wearisome to the Bodies, but burning for the Fields, with drying Winds predominant. This will be better understood by considering, for how many days the Barometer was high, above Thumbs 27, and line nine.

At Thumbs 27, and one line the day August 27.

At Th. 27, and 1. 8 the days May 13, 29, and 31.

At Th. 27, and 1. 8 and a half the days May 30, and August 16.

At Th. 27, and 1. 9, the day July 24.

At Th. 27, and 1. 9 and half the days June 1, and August 17.

At Th. 27, and 1. 10 the days May 11 and 12, June 2, 8, and 11, July 1, 2, and 17, and August 18.

At Th. 27, and 1. 10 and a half the days May 20, 26, and 27, and August 1, 4, and 15.

At Th. 27, and 1. 11 the days May 10, 14, 21, 25 and 28, June 7, 9, 10, 12, 17, 18, 25 and 29, July 6, 7, 9, 16, 18 and 23, August 2, 12, and 13, and September 7.

At Th. 27, and 1. 11 and a half the days June 3 and 19, July 8, 10, and 11, and August 11.

At Th. 28, the days May 15, 18, 19, 23 and 24, June 4, 6, 13, 16, 20, 21, 24, 26, 28 and 30, July 3, 4, 5, 12, 14, 15, 25, 26 and 27, August 1, 3, 4, 5, 10, 24, 29, and 31, and September 6, 8, 9, 10, 15, and 27.

At Th. 28, and half a line the days May 7 and 22, June 5, July 13, 19, 28, 29, 30 and 31, and August 6, 19, 25, 26, and 30.

At Th. 28, and one line the days May 9 and 17, June 14, 22, and 27, July 20, 21, and 22, August 7, 8, 9, 20, 21, 22, 23, and 28, and September 14.

At Th. 28, and 1. 1 and a half the days May 8, June 23 and September 2, 11, and 26.

At Th. 28, and 1. 2 the days May 16, June 15, and September 16, 20, 21, 22, 24 and 25.

At Th. 28, and 1. 2 and a half the day September 23.

At Th. 28, and 1. 3 the days September 17, 18, and 19.

The first 72 days of the Summer were [as follows].

Clear the days May 7, 8, 9, 11, 16, 18, 22, 24, 25, 27 and 28, June 2, 3, 4, 5, 11, 14, 16, 18, 20, 21, 22, and from the 24th to the 30th, and July 1, 5, 6, 8, 10, 11, 12, 14, 16 and 17.

Clear but with Clouds of long duration the days June 9, 10, and 15.

Variable from Clear to Cloudy the days May 14 and 31, June 6, 12, 13, 19, and 23, and July 2 and 4.

Completely Overcast the day May 10.

Rain the days May 12, 13, 15, 19, 20, 21, 23, 26, 29, and 30, June 1, 7, 8, and 17, and July 3, 7, 9, 13 and 15.

In the remaining 72 days of the last half of Summer, the Weather went forward thus.

Clear the days from the 8th to the 23d, and from the 25th to the 31st of July, the first four days of August, from the 6th to the 10th, the 13th, 14th, and 15th, from the 17th to the 20th, from the 22d to the 25th, and from the 28th to the 31st; from the 1st to the 6th of September, the 8th, and from the 11th to the 27th.

Variable from clear to cloudy the days August 11, 12, and 21. With brief Rains, and local the days July 24, August 5, 16, 26 and 27, and September 7, 9, and 10; and it was notable that early in the morning of the day August 5 there was a very evil [looking] cloud on the Alps, which caused great damage to the Chestnut Trees. There was also Darkness of the air over Florence; two hours after mid day it drizzled somewhat, then cleared up, and the Temperature of the Air was so troublesome, that the night and the day after made one restless.

I have not been able to spare the Readers so minute, and tedious a specification of the condition of the Atmosphere in our Summer of 1766, because precisely in this Summer, and mostly in its first half, there occurred that abundance of the Rust, the damaging Fogs, and the Dews, which ravaged the Fields.

The Rains then, and the Winds from the West, which predominated during almost all of the indicated first half of the Summer, mostly toward evening, varying in speed, and direction, maintained a continuous sucking up of aqueous Vapor into the Atmosphere, and induced a coolness very irksome to the Body, especially in the morning hours, during which there would almost always be abundant Dew, or Clouds more, or less dense, and lasting.

On the day May 25, in the lower and colder places of our Countryside, some appearance of the Rust began to be discovered on the leaves of the Wheat. The days 29 and 30 it rained excessively. The day June 1, marking the last quarter of the Moon, there was dense Cloudiness, and acute cold, and on the 2nd, some little more of the rust was seen. On the day June 8, following the New Moon, after a universal Fog, very dense, cool, and humid, that began in the night,

maintained itself until 10 o'clock in the morning, and dissipated when a cooking Sun appeared, there appeared on the Wheat a notable quantity of the Rust, not only on the open Plains, but also on the Hills, that commenced to make the Countrymen apprehensive. But the morning of the 15th, the day having been predominated by cool Winds from the West, at 5 o'clock there arose a very dense and dark Fog, cool humid, and stinking, and it maintained itself, in our low Plains until towards mid-day; thereafter a very beautiful Sun being uncovered, with very hot air, and without Wind, suddenly a great precipitation of the Rust was seen, which universally carried away almost three fourths of the expected Harvest of Wheat, not only from the more fertile grounds of our Countryside, but from the whole of Tuscany, and a large part of Italy. During the remainder of June, and until the 18th of July, on which began a furious Dogdays [period], maintained for 29 days continuously, we can not say we had one entirely good day, for almost all of them appeared with dense and cool Fogs in the morning, and were in the remainder subjected to sudden and swift changes of Clouds, Clearness, vexatious Southwest Winds, of cool Maritime [West] Winds, tempestuous Southwest Winds, and intervals of cooking Sun, and Rain, at times excessive, at times light. In such a great intemperance of the air, I saw new Rust appear both early, and late, not on the Wheat, which was already torn and harvested on our low Plains and Hills, but upon other Plants which I shall record hereafter, and, which is worse, the *Volpe*,[1] the Morning Dew, and a world of malicious Insects, which diminished in large part the important Harvest of the late Oats, also conspired to damage the Fields.

The appearance, and propagation of the Rust on the Wheat was not restricted to the half of June alone; it progressed always successively swelling, and in the remainder of this month, with great velocity, to the Plains, and to the Hills rising to the Mountains, for it is undoubted that in the *Mugello*, a cooler country, with respect to the Low Plains of Florence, on the day of July 6, the Wheat was very beautiful and sound, but on the 7th it was also, as ours, being bruised by the Rust.

As then the Rust is the most serious, and the most formidable Malady of the Wheat, and of many other Corns, speculations that can be made upon it, will help much to explain certain similar Maladies of this Plant; therefore first I shall explain briefly the

[1] *Volpe, fox.* There is no adequate translation. The word appears to have specific reference to smuts of the types represented by stinking smut and bunt of wheat and covered smut of oats and is today the common name in Italy for bunt. —L.R.T.

structure, and natural organization of the clean and rank-growing Plant of the Wheat, but only of that portion which appears above the ground (since on p. 253. I shall speak sufficiently of its roots) and of that which I have observed, and found out with the greatest attention possible, the better to explain the form of the Malady, that the Greeks named *Erisibe*, the Latins *Rubigine*, and we *Ruggine*, from the similarity that it has in color with the Rust of Iron. The Lombardians name it *Malume*, or *Melume*, the English *Mildew*, the French *Ruille*, *Nielle*, or *Nouille*, the Spaniards *Orujo*, the Flemish *Roest*, and the Germans *der Rost*.[2]

The Corn, or Wheat then, and all the other Cereal, Culm-bearing Plants of the same class, are organized in the same manner, that is their Culms, Reeds, or cylindrical Strings,[3] are woven of a certain series of parallel longitudinal fibers proceeding from below upward, swelling a little on the surface, of a deeper green in the living Plant and whitish in the dry. Of these I have counted 32, and 36, and even 40: some are simple, others are composed of two, three and four minor series, all situated on the exterior surface of the Culm, or *Canelet*, of which they form the skeleton, being harder than the rest [of the culm], and somewhat woody. The intervals between one and the other of these longitudinal fibers, are a little sunken in the manner of channels in a column, and are formed of a well ordered series of Tracheae or Utricles, that are transparent within, and from time to time have certain thin Diaphragms, that form a kind of almost transparent net. This appears better in the young plants, succulent and green, but in the mature and dry straw, even and smooth, only the longitudinal extent is distinguishable. The discrete intervals, that are a weaving of the principal and master Arteries of the Plant, and of the elastic air receptacles, called by the Great Malpighi *Tracheae*, are densely punctuated throughout with certain things like pustules, not distinguishable with the naked eye, but that examined with a sharp Lens, appear exactly the shape of an Egg yolk, filled with a transparent liquid. All this external surface of the Wheat, woven as I have said, is covered by a very fine, and transparent, Cuticle made like a net, that cannot be distinguished nor separated, except by a malady, like the Rust, and by the gnawing of some Insects. This Cuticle is all densely sprinkled, and without regular arrangement, with certain hemispherical Vesicles, filled with most limpid water, not discernible except with a very sharp lens, and fifteen times, about, smaller than the little Semiovals described later which are situated in rows. From the external crust,

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[2] See *Ginanni delle Malattie del Grano in Erba Par. 1. c.1. p. 8.*

[3] *Idem Par. 2. c.12. § 12.*

or fibrous skeleton of the Canelet of the Wheat, there propagates towards the axis of the same Canelet a marrow-like, whitish, spongy substance, of the fashion of the marrow of the Buckwheat Stem, composed of Utricles, and of Vesicles full of air, which in the *Tame* and *Big* Wheat, in the Barley, and the Oats, only lines the interior of the Canelet, but in a kind of Ravanese Wheat, in the Great Rye, and in some other Cereal Plants, fills the whole. At the summit of every node, the Fiber which I said was somewhat woody, enlarging, and bending outward, forms a rim or cornice, and the marrow enlarges here also, and unites one point to another, forming a partition wall, or hard Diaphragm, that is the end of a Canelet, such as occurs in the Cane. Above this Diaphragm, the superior Canelet is implanted, the beginning of which is a little narrower, and within the height of a line 13 or 15 little hemispherical bubbles become visible, which project out from the described series of somewhat woody Fibers, which to give passage to them curve somewhat and spread apart. These little bubbles have a kind of rim or cornice, a little hardened, that in the living and rank-growing Plant, appears rather dark green, and in the middle they also are filled with a dark green liquid; in the dry plant, however, or the diseased, there remains visible only the rim or cornice, but the hemisphere collapses inward, and appears as a small saucer of filthy color, a sign, I believe, of the moisture which filled it, and made it swollen in the form of a hemisphere, having been exhaled. These are the Eyes, which as noted above on page 253 in the radical nodes, or those closer to the ground, become roots, and new shoots, and with the help of which multiplication of the Stalks of the Wheat occurs;[4] but on the high nodes there would also be produced Eyes bearing Branches, as in certain sorts of Cane, if they would have the season for the purpose. In correspondence to the described interval of the Canelet, where the Eyes appear out of it, one sees within a white stuffing in the manner of Buckwheat, that with the Microscope appears as a weaving of little Bottles made of leather, of Vesicles full of air, and of arterial canals. In correspondence likewise to the same interval of the Canelet, from the rim which serves to confine the lower Canelet, there propagate about 34 projections of Fiber similar to those of the Canelets but larger, pulpose, and green, with very narrow intervals between them, and all together they are the base, or the beginning of the leaf that covers the Canelet. They proceed thence loose and large, forming a Cylinder united for the height of about a line and a half, and then make a rim or projection, on which the Cylinder bursts with a little buttonhole in the part opposite to the

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[4] *See Ginanni delle Malattie del Grano in Erba Par. 2. c. 12. § 7.*

leaf of the Node below, whence all go upward united, and become the sheath of the leaf. This sheath is on its outside formed in the same manner as the Canelet, that is hard fibers continuing for the length [of it], and projecting, with intervals a little sunken, and strewn throughout with Semioval Vesicles and other very numerous exceedingly minute Vesicles, Semiglobose, scattered over the whole cuticle, and with some very short hairs scattered throughout the extent of the Fiber. The interior of the Sheath, where it touches the Canelet, is smooth, and lined with a kind of Membrane, composed of material similar to the marrow of the Canelet, but where it ceases to clothe the Canelet, this interior membrane swells out in the manner of a little collar. The crest however of the sheath, after a kind of narrowing to a throat makes a bend, turns outward, and becomes a long and slender Leaf, composed above, as below, of 45 hard longitudinal Fibers, swelling outward a little, but with the one that rests in the middle of them all, much more enlarged and swollen than the others, in the form of a rib, with partitions somewhat intrenched on both faces, composed of vascular and bladder-like parenchyma, similar to that of the Canelets. Not only the leaves of the Canelets, in the Latin called *Stipulae*, but also those higher, that bear the Spike having the blossoms, called in the same *Vagina*, are organized in a manner identical with the outside of the Canelets, but have besides the Cuticle all raised up in semioval Vesicles, disposed in rows in the partitions, and other very much smaller semiglobose Vesicles, scattered densely everywhere; and have only the most minute and short hairs. Four only are commonly the Canelets of the Wheat above the ground, and four are the leaves, that is one that issues from the second radical Node, and three on the contrary, that are borne at the lower Nodes. The last Canelet, or highest, has in its summit a throat, and makes a kind of Node, on which arises another portion of Canelet, not taller than about four lines, but divided in two, and one part hollowed to a niche, and full within of marrow. This short hollowed portion of the Canelet, weaves at its summit another similar [portion], but reversed, and this sends out a third, and the third a fourth, all alike, up to 22 and 25, which face always to the reverse of the hollowness, forming the rib, and the axis of the Spike, adorned with small hairs on the hems, filled within by marrow, more elongated in the Gentile Wheat, shorter and larger in the Egyptian Wheat. At the base plate of every one of the niches of the Spike, there break out laterally two leaflets that face each other, are made in the shape of boats, hard, and somewhat cartilaginous, smooth within to the naked eyes, but with the Microscope all blessed with small transparent blisters; on the outside then troubled, and almost whitened by a greater abun-

dance of these Vesicles, greatest on a certain fibrous rib that it has, and toward the point. These little leaves which the Latins and the Botanists call *Locustae*, or *Glumae*, and we vulgarly call *hull*, serve as the Chalice, or Custodian of a secondary spike, similar in large part to the main one, but that commonly has five levels, except that in a certain Wheat decreased by disease, I have counted up to fourteen. At the niches of each of these secondary Spikes, except the first, and the last, which almost always have disappeared,[5] there spreads out a *Locusta* or *Gluma* made in the shape of a boat, and in certain kinds furnished with a long spiny Awn,[6] that in its bosom guards the little Kernel of Wheat by the humped part, with the Germ turned inward, and the two Petals, and Stamens, and over the creased part of the little Kernel is another more delicate and smaller glume, a little hollowed internally. In our Clime, regularly, and in good years, every secondary Spike of the Wheat imposes two, that is perfects two Kernels, as in the Gentile, or imposes three as in the Egyptian Wheat; and as these Kernels occur disposed in levels and in rows, the Botanists call *Triticum Tetrastichum* that which perfects two, and *Exastichum* that which perfects three, and the Kind of Spelt that perfects only one Kernel per part, is called *Hordeum Distichon*. In Egypt moreover, in Mesopotamia, and in certain places in Sicily, some of these Secondary Spikes develop completely all the small Kernels that they have, and then the principal Spikes become as a bunch of grapes. This Wheat like a Bunch of Grapes, or with Brush, is pictured by Lobelio,[7] and is called by Gio. Bauhino [8] *Triticum cum multiplici spica, glumas facile deponens:* of it treats also the Ab. de Vallemont,[9] and M. Duhamel du Monceau,[10] who calls it Wheat of Smyrna. It is not believed however, that this is a particular and constant kind of Wheat; it is only a variety, that depends on the goodness of the soil, and the Climate, as notes also Sig. Dodart.[11]

I being humble, it was helpful to me, that Doctor Benedetto My Father had a donation of a *P. Minimo* that came from Sicily, an envelope of Wheat *a Grappoli* of that country, and he sowed this in

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[5] The Kernel at the apex of the Spike, which almost always is empty, was called *Frit,* in Latin, and the lowest kernels, or those at the bottom, also being empty, were called *Urruncum*.

[6] *Arista* according to the Latin was the Awn; *Spica Aristata* that with the Awn, and *Spica Mutica* that without the Awn.

[7] Ic, 26.

[8] Hist. Gener. Plantar. L. 18. p. 407.

[9] Curiositez de la Nature & de l'Art sur la Vegetation T 2. p. 141.

[10] Traité de la culture des Terres p. 195.

[11] Memoria sopra la moltiplicazione de' Corpi viventi, considerata nella fecondità delle Piante, fralle Memorie dell'Accademia Reale delle Scienze del 1700. p. 184.

the Garden of our Villa di Settignano, which was of rich soil, and well worked. Of the stalks of this wheat I recorded that they became very large, full of marrow within, tall as a Man, and made Spikes of a prodigious size, like seven or eight secondary Spikes all grouped together, and from only one paper cup of seed, that will be three ounces, there was harvested almost a sack of wheat. This so very much encouraged my Father, and the Countrymen, that they planted in November all of this Wheat in their Power, hoping wonders of it; but they were deluded, for at the Harvest it yielded no more than the ordinary Egyptian Wheat. This notwithstanding, it could serve as a rule, for anyone to have the custom of obtaining every year from Sicily, by means of trusted correspondents, the Seed of the Wheat *a Grappoli*, and sowing it in good soil worked as it ought to be, because there always would be a great profit from having the first abundant harvest. More commonly in the Spikes of the Great Wheat in our country I have counted 22 grains on the one hand, and 24 on the other, and in the Gentile 20 on the one, and 24 on the other; and Cammillo Tarello [12] noted, that Wheat has commonly in each Spike 50 Grains; hence, should each planted Grain grow, and produce a single Spike at least, each Bushel would be increased by Fifty: but who has this fortune?

I fear that this minute exposition of the Structure of the Wheat, will have proved a little wearisome to some Readers; but I could not save them this tedium, because precisely from this structure more easily will they come to understand the nature of the Rust, and of how it produces effects considered harmful to the Wheat. At the proper place I noted scrupulously the series, or rows of semioval Vesicles, situated everywhere on the leaves, and on the Canelets of the Wheat. These Vesicles precisely are the place, where, from all I have been able to discern, the Rust produces itself and nestles. Certainly the little groups or masses, I have found situated under the Cuticle of the Wheat, as well on the Canelets, as on the Foliage, on the Chaff, and on the Beards, and notably in the hollows of the utricular Parenchyma, that lies inserted between the tracts of longitudinal fiber, and in the place precisely, where in the healthy Plant the semioval Vesicles would be seen. There the Rust either is borne, or is deposited within a small ditch, or kind of subcutaneous oblong, hollow sore, elongated parallel to the axis of the Canelet, or of the foliage, within the above mentioned utricular Parenchyma, which it corrodes and consumes. In its first origin, and in its Infancy so to speak, the Rust appears in the form of a point, or of a little line of bleached yellow color, that is hardly distinguishable. This so

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[12] Ricordo d'Agricoltura p. 9.

tiny spot, amplifies speedily in all dimensions, and especially toward the external surface of the Plant, where it swells in such a manner, that it separates the Cuticle from the Parenchyma, raising up a blister, such as the Vesicatorial Medications make on us; and finally makes it crack lengthwise in one or more places, and tear in the form of very delicate transparent spangles, and is wrapped in a coronet; and then the Rust is rendered visible to our eye, in the form of a very fine, more or less orange colored powder, as I shall say hereafter. How rapidly this augmentation of the Rust proceeds, I have not been able to verify; only I know from practical persons of the Fields, that it occurs with incredible velocity, that is in a few hours; because, to cite an instance, if the Wheat had been very beautiful, and very healthy, and there had predominated in the course of the day Winds of the West or *Ovest*, the same as the West, or any other of its Collaterals between the South West and North West, and it had been calm towards the setting of the Sun, or a little after, and this night there came towards the dawn a Cloud, such as the Countrymen call wicked, that is that falls in the form of very minute droplets of Rain, wetting the rocks, and leaving all the Plants close to the ground covered by very minute droplets of water, and then at mid morning there bursts forth a sphere of cooking Sun, and unless some Wind rises, immediately the Rust shows on the grains in great quantity.[13]

When the Rust has been rendered visible to our eyes, by the tearing of the Cuticle of the Wheat, it appears a beautiful, bright yellow, which soon becomes orange, or *suci* as is said today (since it is the necessary style to change good old Tuscan words, into modern French); then with the extent of days it passes to the color of Dust and afterwards to that of Ground in shadow, or is even darker, and deepens finally to black, in proportion as the Rusty Chaff is near to or far away from the ground, and is dominated by Rain. As far as I have been able to ascertain, the Rust after splitting the Cuticle of the Wheat, becomes stable, and does not increase in quantity, nor in mass, but quickly diminishes, because a great part of it pours out, and scatters over the continguous surfaces of the Wheat, and on anything that touches it, and is carried away easily by Winds, and by Rains. It appears that the Rust may increase depending on the successive days it generates anew; but one such bunch formed today, for example, certainly does not grow, nor distend more than to its final fullness, which it has attained to cause the Cuticle to split.

From this it is understood, that the Rust is an intercutaneous

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[13] See Ginanni delle Malattie del Grano in Erba Par. 3. c.1. § 1. p. 284.

Malady of the Wheat, and also it will be seen shortly of other Plants of very diverse structure. Without being concerned at the moment with investigating the cause, and the nature, and explaining the effects, I shall relate briefly the Microsopical observations I have made.

I began the day June 11, with a microscope of three Lenses, made by the famous Giuseppe Campano, that owned by Doctor Benedetto my Father, and that he made available to me everyday; and with a very sharp Lens, that was given to me by my good Friend Doctor Pier Francesco Ricciardetti Aretino, a young man of very great expectation in Mathematics, and in Physics, who to the great sorrow of good men, was carried off by death while far too young. Quickly I came to know that the Rust was an aggregation of very minute little bodies of a form almost oval; but not being able to satisfy myself as much as I wished, for lack of the necessary equipment in instruments, I entreated Sig. Doctor Raimondo Cocchi public Professor of Anatomy, and Antiquario of the S. A. R., to examine the Rust with the good simple or Aquatic Microscope of George Kuff. He kindly favored me by doing this, along with Sig. Doctor Ranieri Maffei Livornese, but they saw little more than I had seen with my glasses, without being able to determine the nature of these little bodies, that is whether they were Plants, or Animals. I had recourse then to the kindness of Sig. Doctor Carlo Alfonso Guadagni, Public Professor of Experimental Physics in the University of Pisa, who also has in Florence a copious assortment of the most perfect Microscopes. He kindly gave me the opportunity of making whatever observations I wished, and with his large practice and skill, he made it easy for me, and rendered demonstrations.

To obtain the greatest, and at the same time most distinct enlargement of the Little Bodies of the Rust, Sig. Doctor Guadagni, from among the very beautiful Microscopes which he possesses, selected that duplicate of Gio. Kuff, made by George Ayscough, one similar, but even better, made by Francesco Watkins, one marvelous as a Little Pearl made by Giorgio Lindsay, and also the Solar of Doctor Liberkhun, to which he adapted a sharper Lens, specifically the No. 1 of the Microscope of Edmondo Culpeper. The first Observations were made the morning of the 16th of June, at which Sig. Doctor Antonio Durazzini was pleased to be present, and the second the morning of the 18th, when Sig. Doctor Raimondo Cocchi, favored me by designing in water color the objects which the Microscope showed; and the others were made with only Sig. Doctor Guadagni, the mornings of June 27, and July 3, 12, and 19, and August 11 and 13.

The Rust then nestling in the leaves, and in the stems of the

Wheat, was not other than a mass of tiny bodies all of the same shape, size, and color, thus appearing all made with the same mold, without its being possible to distinguish differences of age, or of maturity, and equal to the diameter of a human Hair, whether to the naked eye, or with the Microscope. Their shape was oval, precisely like that of the Date, that is with the extremities rounded, not pointed (see Fig. 1). In the fresh, young Rust, these Date-shaped bodies appear transparent and of a beautiful Amber color, on the surface, as well as within, and are smooth on the outside, not bursting out into projections or any roughness, not even with the Solar Microscope: only with the Solar Microscope, in some of the Rainbows occasioned by the refraction of rays, there is accented a longitudinal striation, like that on the Nuts of the German Apricot (see Fig. 2) and in others an annular, concentric striation of the external hem; but this was the case with a few of these bodies exposed to the greater violence of the rays of the Sun, and therefore actually shriveled and wrinkled. Some others, but rare, showed attached to one of their extremities a certain fine thread, like a little stem or little stalk, of the same color, that appeared cut off at its summit. Diligent effort was made to ascertain whether the described fine thread was an essential part of the Rust, or merely casual, but it was not possible to arrive at the truth, except that the morning of the 14th of July, while examining certain *Volpato* [14] Wheat, there was found on the dry Chaff a Rust not yellow, nor orange, but black as the soot of Smoke. I scraped with diligence a little of this on the isinglass of my Microscope, and immediately saw the single date-shaped bodies; having become because of aridity and old age the color of dark Amber, more meager, more oblong and somewhat pointed at both extremities (see Fig. 3) but what imported more, all had attached to them little threads in the manner of little stalks, which on many were as long as the little bodies, and on others even longer. This same thing was verified in the middle of the morning on the 19th of July with the Microscope of Sig. Doctor Guadagni, and it appeared without equivocation, that every single knot of Rust on the Stem and on the Leaves of the Wheat, is an internal, very tiny, parasitic Plant, which does not arise except between skin and skin, so to speak, of the Wheat, as do the Pellicles, and the Worms of the Mange of Animals. These Tufts of the Rust are borne, and grow only in the precise place, where I have said are found the cutaneous semioval Vesicles filled with water, of which I cannot well say whether they are receptacles for the excretionary

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[14] The noun *volpe,* meaning *fox,* and the past participle *volpato,* meaning *foxed,* refer to bunt and to bunt-infected wheat.—L.R.T.

moisture of the plant of Wheat, or indeed a kind of Ventricle, under the action of the external air, receiving any seasonable preparation of the nourishing humour of this Wheat. This I incline to believe the more readily, since I see that as the plantlet of the Rust takes possession of the described Vesicle, and sucks up, and converts into proper nutriment the liquid that is found there, or that arrives to be disposed of, the impoverished Plant of the Wheat remains without sap, and bewitched, and cannot nurture its Fruit; which should not happen, if the humour of the semioval Vesicles were purely excretionary. Not only do the little Plants of the Rust fill the cavities of the semioval Vesicles, but they also extend somewhat towards the interior, always however in the utricular and vascular parenchyma, not in the hard longitudinal tracts of Fibers which I have called woody, hence the spots of the Rust appear oblong, and they propagate inwardly along the axis of the Canelet or of the Foliage, forming a small cavern, or rather mine hollowed to spoonshape, which is truly a subcutaneous sore of the Wheat plant. The bottom of this sore is not other than a radical crust of the Rust itself, which on the outside is woven of certain very short and delicate rootlike hairs, and they enchase themselves within the arterial vessels, that carry the nutritive humour to the Wheat plant, and there they form themselves. These hairs steal, and suck up for themselves the nutriment prepared, and destined for the Wheat, with that same mechanism, with which the Chokeweed appropriates the nutriment of the *Bacceline* Plant, the Hypocistus that of the Cistus or Rockrose, and the Birdlime or *Pania* that of the Pear, and of other Trees.

The described Radical crust of the Rust, from its internal spoonshaped surface, sends out a large quantity of threads or tiny stalks (see Fig. 4) that from narrow bases become enlarged at the apex in the manner of a Cornucopia, are transparent and jointed, that are composed of two or three internodes, situated vertically one upon the other. The highest of them is the one which enlarges to a cone, and ends in the apex as the Cornucopia, with a somewhat thickened hem, and forms a bowl, on which, as on a chalice, rests on one of its extremities, one of the date-shaped Little Bodies of the Rust, that have already been described. Such indubitably, and without any equivocation, appeared to be the Rust of the Stems, and of the leaves of the Wheat the morning of July 19, and with all the scrupulous diligence we used on this morning, and on others later, we could not come to see otherwise, than that there was only one date-shaped Body, on the apex of each tiny stalk terminating in a Cornucopia. It is however true that the date-shaped Bodies contained in each tuft of the Rust, are so great in number, that if every one of them had its appropriate and particular stalk, or stem, there would be dis-

covered with the Microscope an immense forest of threads or stalks; nevertheless very few of them are seen, and only on the overdone and dry Rust. In the fresh and growing [Rust] on the contrary, immediately that the increase of volume forces the Cuticle of the Wheat outward, and makes it swell, and finally crack in a very delicate spangle, the Rust is manifest immediately to our eye in the form of an orange powder, that pours out from the interior of the opened sore on the stem, or on the leaves of the Wheat, adheres to all bodies that it touches, and then is carried away easily by the Wind, or washed by the Rain. This powder, appears with the Microscope to be not other than an immense number of date-shaped Little Bodies, entirely isolated, and independent, without any attachments or stalks whatsoever; nevertheless they are in every respect like their companions, which on the morning of July 19 we found situated on the apex of the little stalk terminating in a Cornucopia. Would it be permitted us then to conjecture, that in the fresh and living Rust, each of the described little stalks with Cornucopias, sustaining on its apex many of these date-shaped Bodies, but disposed in bunches, or in tufts, goes with those Microscopical Plants, that our immortal Micheli named *Aspergillus*, *Botrytis*, *Mucor* and the like?

Not unknown to the Microscopist is the date-shaped Form of the little bodies of the Rust, because there have appeared also such observations with the light reflected from above, and with the fourth Lens of the Microscope described in the Book by Henry Baker *degli Animali nati nelle Infusioni de' Vegetabili.* With the Lens No. 1. of the Microscope of Edmondo Culpeper, adapted to the Solar Microscope, these very tiny Dates appear divided in the interior into two or three cavities, or cells, longer than wide (see Fig. 5), and show certain things like Diaphragms, that serve as divisions between the cavities above mentioned, and are also filled with a liquid, that when it is of the proper quantity, keeps them swollen, distended, and smooth. This liquid is undoubtedly very limpid, and transparent in the color of Amber, for, having many times crushed a minute pile of the Rust between layers of Crystal, it was seen always with the Microscope, that this liquid unites together in the guise of a yellow Oil, within which is distinguishable the very delicate shells of the date-shaped Little Bodies, entirely empty, or partly so. One other evidence of the existence of such a liquid, is given by the aged, withered, or cut off Rust, whose date-shaped Little Bodies do not appear so perfect, but more delicate (see Fig. 3), more oblong, a little pointed at the extremities, and in thickness a little crushed, and with some angles, according to how they are pressed against each other, and a portion of them are of darker color, because of the condensation of liquid that occurs, and

perhaps also to assist the deposition of the Little Seeds in greater abundance.

Such is undoubtedly, and without equivocation, the make-up of the Rust that is borne on the stalks, and on the leaves of the Wheat. It is an organic body, not casual, or formless: but in all the many times it was observed scrupulously, even taking the fresh plant suddenly from the soil, and it muddy, no spontaneous movement could be recognized, not even the least. None of the Little Bodies that constitute it, have given an early or late sign of life, that is of feeling, or of voluntary motion,[15] even though incited, pressed upon, infused in water, in the Oil of the Olive, in the Spirit of the Vine, and in the Acid of the Lemon, and even though exposed to the heat of the Solar Microscope, where only it promptly withered, and became wrinkled. On the other hand, in a drop of water exposed to the same Solar Microscope, in which Sig. Doctor Guadagni held in infusion a bit of bark of Quercus, suddenly there were seen to move in all directions, with very great velocity, certain minute animals of the shape of the Tortoise, and with gentle movement certain other larger ones, of the shape of the Seeds of the Gourd. The date-shaped Little Bodies of the Rust do not have anything at all in common with what the Illustrious de Buffon has so wonderfully illustrated, and named *Particelle Organiche viventi*,[16] nor with that Class of Animals discovered and observed by Nehedam, and Baker, nor by Sig. Abbot Lazzero Spallanzani. It should be added that they do not show any orifice, by which they could suck in food, or expel the superfluities of nutrition, or propagate their kind, such as would be supposed of Animals; and among them is not seen any difference that can be credited to sex, or age, which moreover there ought to be, such as would also be supposed of the very bizzare Class of the famous Polyps of sweet water, that are believed to multiply by being cut, or of the Lice of Plants, named by the French *Pucerons*, which are viviparous.[17] Not even is there motive to believe that they might be a race of Insects, that fasten themselves, and adhere one to the other, like the Little Gourds, which form diverse kinds of Tapes, or like the Microscopic Coralloids of Nehedam, because having ruptured the cuticle of the Wheat that covers them, they find themselves free and independent, suddenly pour out in the form of powder, spread over the environs, fall easily downwards, and with every little shock of the plant disperse. Only when they

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[15] That such would be Animal motion see de Buffon Histoire Naturelle T.2. Par. 1. p. 385.

[16] Ibid. T. 2. Par. 2.

[17] See de Buffon Hist. Natur. T. 2. Par. 1. p. 13, 81, 414, & 462. Ginanni delle Malattie del Grano in Erba Par. 2. cap. 9. § 50. p. 194.

are fresh and formed but a little time, and well filled with sap, has their surface although smooth, any oiliness or adhesiveness, by which they remain attached for some time to the surface of the Wheat Plant, to the Insects that come near, to the Isinglass of the Microscope, to the little knives with which they are gathered etc. When then they become dry and old, probably they decay like glue, because in the threshing of the Wheat, they fly away in the form of rusty Powder, or unitedly remain attached to the little black sores of the Chaff, a little of which are here implanted, and remain fixed to the little stalks described as formed like Cornucopia.

Sig. Count Francesco Ginanni [18] is the only person who has observed the Rust of the Stems and of the Leaves of the Wheat, and he described it with exactitude at 7, without however recognizing it for Rust, anticipating the idea that the Rust would be caused by Little Worms. He moreover [19] recorded three sorts of Rust, which if confronted with my description, will be recognized not to be other, than one and the same, seen in three diverse ages. The reason why this Very Learned Cavalier, of such high merit in Natural History and in Agriculture, did not come to understand well the nature of the Rust, although he had taken such great pains, is that he was not provided with perfect Microscopes.[20] It appears that the Great Malpighi described the Rust, without however calling it such,[21] in these terms: *In Frumenti Culmo per longum tumor eminet, turgentibus Utriculis atro et aeruginoso intus contento pulvere, qui tandem lacerata cuticola foras dispergitur, et gemina quasi Vulnerum labia, parum distantia, et secundum rectitudinem sibi correspondentia erumpunt: intermedia vero Fistulae pars non parum gracilescit.* M. Aymen [22] saw the little globules of a kind of Rust of Wheat, with rotund fruit (at that time M. Aymen did not understand by the general term *globules* the Date-shaped Bodies) which he believed to be self-moving particles of the liquid of the Plant. *J' ai pris*, says he, *deux à trois gouttes d'eau, que j'ai mises dans le verre objectif concave du Microscope: j'ai examiné attentivement si cette eau ne contiendroit pas quelque Animalcule, et après n'y en avoir vû aucun, j'ai enlevé, avec un Canif, la matiere des taches noires de la Paille, et je l'ai mise dans cette eau. J'*

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[18] Delle Malattie del Grano in Erba Par. 2. cap. 11. § 7.2. and 3.

[19] Par. 1, cap. 1.

[20] See Par. 2. cap. 5. n. 78.

[21] De variis Plantarum Tumoribus p. 134.

[22] Second Memorie sur les Maladies des Blés nel T. 4. des Memoires de Mathematique & de Physique presentées a l'Academie Royale des Sciences par divers Savans p. 368.

ai observé, que la matiere de ces taches est un composé de petits Globules ronds, qui se meuvent persque du premier moment qu'ils sont dans l'eau, avec moins de force à la verité, que ne sont les poussières des etamines. With the microscopes of Sig. Guadagni, this motion of the Globulettes of all the Rusts was seen many times, and of all the other Parasitic Little Plants described herein; but it was clearly recognized, that such movement is purely accidental, and dependent on the movement of the water in leveling itself, and on the explosion of the air enclosed within the Globules, that occurs as the same Globules absorb the water by which they swell up.

Not even the Spike of the Wheat is safe from the Rust, and not even the Chaff, or glumes, which enclose and protect the kernels, although of so delicate texture, and somewhat cartilaginous, nor are the awns, although fine, and of little succulence. I have found them fuming on the axis of the Spike, on the little main rib, and on the points of the external glumes, and finally all over the Awn, but always in those places precisely, where the aqueous semioval Vesicles abound. All of the Rust of the Wheat described thus far, is of one only and the same date-shaped form, and of equal size, varying only in what little degree it is charged more or less with color, according to its greater or less age; and it is in all respects like the Rust, which I found the morning of July 30 on the Chaff of the Barley, brought from the Oak Forest, in which was seen very clearly the little stems, or little stalks which support the little globes. Another quite different kind of the Rust, of which more will be said below, nestles only in the spikes of the Wheat, and is rather common to many other Vegetables; below I shall record only a few other kinds of Rust observed by me, that are very similar to the date-shaped [Rust] described up to now on the Wheat and on the Barley.

On only the lower surfaces of the Leaves of the Rosebushes, in my Garden for the Repose of the Aged, I found on the day July 3 many fumings of a Rust of a very beautiful gold color, which upon examination with the Microscopes of Sig. Doctor Guadagni, were revealed as a very pleasing kind of Rust, similar to that which nestles only in the glumes of the Wheat, which I shall describe later; and until then not give further demonstration. But the morning of the 30th, re-examining with my microscopes all the Vegetables infected with Rust, which I had collected, to record the variety methodically, I discovered on the same leaves of the Rose, besides the golden fumes, certain others different, and black, of which in the past there had not been the least sign. With the Microscope these appeared (see Fig. 6) to be little tufts of a second, and new kind of Rust, much less branched than the first kind, that implants itself with a root-

like base in the vascular Parenchyma of the lower part of the leaf of the Rose, sending outward certain little simple stalks, or stems, that are not branched, round, articulated, with two internodes, transparent as water, which on the Isinglass wither quickly, and crumple, because of their delicate texture. The lower of the internodes of each little stalk is swollen, and ventricose, in a certain manner like the capsule of the Horseradish; but the higher, which carries one Fruit on its apex, is perfectly cylindrical, and a little less transparent. The Fruit is a little body at least ten times bigger than the stem, of the shape of an Acorn of *Istia*, or of certain Jewish Gems, that is cylindrical with the extremity rounded, and with a kind of little point at the summit, transparent like the stalk. All then of the body of the Fruit appears filled with the color of wine, and not transparent except a very little, and cavities are not distinguished, although I have procured a good swelling with water; but I cannot decide whether such opacity depends on Old Age, or on the maturity of the Seed contained there. The day August 16 I found very much of this second kind of Rust, on the Rose Bushes of the Royal Garden of Simples, where on the day July 11 I did not succeed in seeing any.

In the year 1766 Cereal Plants were not the only Plants damaged by the Rust, for I found it also on many Leguminous Plants, known to the Countrymen by the name *Baccelline*. It is notable, that in the course of the Spring of 1766 the Beans, whether the Winter variety, or those sown in March, were generally but little damaged by Chokeweeds, because from the Day February 20 until March 20 there was dry weather, with the exception of a little rain on March 3 and 4, and from then on through half of May, when that is to say the emerging of the Chokeweeds from the soil came to an end, there were interpolated among the 56 days just 23 with Rain. But in contrast the Beans were also afflicted by two kinds of Rust, that is to say one on the stalks or stems, and branches, and on the ribs of the leaves, which I shall record as the third kind of Rust, and it I found at Malavolta on the day June 27. The Stalks then or stems of the Bean, were seen bespattered with certain little dark spots, situated lengthwise of the fiber, stretching not more than one line, and in the middle they showed a crack or fissure opening in the cuticle of the plant. Raising with care the dislocated Cuticle within this fissure, there was found below a spoon-shaped cavity, that is a wound, or consumption of the substance of the stem, and in this there was found buried a blackish radical crust of the Rust, which sent up certain Threads (see Fig. 7) or very delicate little stems, transparent but a little suffused with yellow, articulated with two or three internodes not swollen, but almost cylindrical, except that the

highest internode was enlarged at the summit a little bit, and formed a kind of little chalice. In the little bowl of this chalice rested upright a fruit of a form almost Olive-like, but with the point or summit rather larger than the base, of the shape of a Fig, about eight times larger than the little stalk, transparent in the color of clouded Amber, and filled within by a yellow almost oily liquid, that manifested itself upon the crushing of this Fruit between two Crystals. Some of the little stalks or little stems of this kind of Rust, appeared to me cut in two, but I can not guarantee whether this was truly the case.

Like this rust of the Stalks, appeared to me the certain one which I found in the same Manor of the *Luogotente Fiscale* Ippolito Scaramucci, the day June 27 on the strong Fennel, on the superior part of the principal veins of the leaves, and all over the sheath of the leaves, in the form of pock-marks, or of sunken spots, oblong, dark, and dry, without any cracking the Cuticle, I do not know whether from the little plants of the Rust being immature, or from the excessive hardness of the Cuticle of the Fennel, the plant being also stunted, and a little withered. The following morning in the House of Sig. Guadagni I scraped with care the dark material of these little sores, and with the Microscope it was seen to be a paste of mucilaginous material, with several little globes of the Rust, in the shape of an Olive flattened at the apex, transparent in the color of charged Amber.

It is something worth pondering, that in this Calamitous Year, Sowings of Rye only, or of *Segalato*, that is to say of Wheat and Rye, were immune from Rust, and I have understood that in the Valdinievole, those who had sown *Segalati*, had a very beautiful Crop, in which the Wheat was the finest to be seen in Tuscany. The same thing happened in the *Vecciati*, that is to say Wheat sown along with Vetch. It is not so easy to render a reason, why Wheat growing seeded with Rye, or with Vetch, was not damaged by the Rust, while a Field of Wheat alone, standing between one of Rye, and one of Vetch, yielded scarcely any seed, and that the most miserable. The saying that Rye is by its nature exempt from the Rust, or at least is little subjected to it,[23] as also Barley, is not conclusive, for Count Ginanni [24] asserts, that Rye and Barley are ill-used by the Rust, equally with Wheat. Certainly the Stalk of Rye is much thinner, that is to say but little juicy, and being so much taller than the Wheat, is more dominated by the Winds, and therefore perhaps the seeds of the Rust do not happen upon good soil.

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[23] Plin. Hist. Natur. L. 18. c. 7 & 10.

[24] Delle Malattie del Grano in Erba Par. 2. cap. 5. n. 25.

I also intended to say, that the Oats remained in this year 1766 immune from the Rust, and there were seen in the Plain of Florence very beautiful Fields of Oats clean and rankgrowing, in the midst of Fields of Wheat consumed by the Rust. I found however on the day July 11 some rows of Oats, that were infected on both the faces of the leaf only by a Rust, of a fine yellow color, or bright orange, situated in Vesicles, or oblong pustules, elevated in their surfaces, pointed like the first kind on the Wheat. It was different moreover from the three which up to now have been described, as its Fruits (see Fig. 8), sustained on a very slender little stalk or little stem entirely transparent and cylindrical, were smaller by half than those of the Rust of the Bean, transparent in the color of clear Amber, in shape perfectly Olive-like, with the two extremities a little flattened, and smooth; and therefore I record it as the fourth kind of Rust.

For the fifth I shall consider one with the heads, or fruits likewise Olive-like (see Fig. 9) but more oblong, and pointed at both extremities, transparent in the color of dilute Amber, with little cylindrical stalks a little coarse, long and curved, and of the same color, among which I found standing intermixed some nodose fine hairs, like rows of Beads, if one may say such a thing. I discovered several very minute tufts of this kind of Rust, buried in both of the faces of the leaves of the Plum Trees in the Royal Garden of Simples, and in my Garden of the Repose of the Aged, on the days August 16 and 17, and noticed that on the upper faces of the leaves, in correspondence with the nests of the Rust, there were little, round, yellow, dry spots.

The sixth kind of rust infected both faces of the leaves only of the Bean, in the form of tiny pustules the size of a grain of millet, of the color of the Dust, that then became dark, and this was discovered on the day July 3 on certain rather dry Beans in my Garden of the Repose of the Aged. These little pustules are tufts of the plantlets of the Rust, which growing, and feeding on the sappy substance of the leaves of the Beans, increase to the point of making the cuticle of the leaf crack in the manner of a Scale, and then globules spatter out, which appear with the Microscope (see Fig. 10) of a shape somewhat Olive-like, of the color of Amber, on the surface not smooth, but with a light advertisement of little knobs, or little protuberances (see Fig. 11), sustained by slender stems, or stalks articulated and transparent, by which they are attached to the root-like base. The globules crushed between two layers of Crystal, are seen under the Microscope, to have within a yellowish sap, which as it becomes old and dry makes an opaque spot at one place. Many of the more succulent globules, appear to be globes compressed in the middle, and bordered by a cracknel (see Fig. 12) and thus also they remain when wetted with the Spirit of Wine. The Oil of the

Olive moreover penetrated them quite rapidly, and caused them to swell a little, and become little bladders flattened on one side. In the summit of some of these Tufts of the Rust of the leaves of the Bean, I discovered with my Microscopes certain particular soft hairs, different from the Rust, which with the very sharp Microscope of Sig. Doctor Guadagni, gave a graceful spectacle, for they appeared to us not to be other than a kind of thread a little enlarged (see Fig. 13), diversely bent, in the manner of an Eel, or of that kind of Caterpillar that is named Measuring. It is most marvelous, that these little threads are not other than series, or rows of very minute little bodies, that is to say more crowded by fifteen times at least than the little globes of the Rust, transparent as Crystal, and of the shape of the stones of Dates (see Fig. 14 and 15), which situated lengthwise, one after the other, to six and seven and eight rows, and touching reciprocally with their surfaces hanging together, come to unite, and form a kind of thread like a soft hair. There are not distinguishable between these little bodies links, or attachments of any kind, except the already noted kind of viscosity of their surface; but it was recognized clearly, that they are not a kind of *Cucurbitini*, which follow close at heel the one to the other, forming a *Taenia*. Aggregates of them readily discompose, with the pouring on them of a little drop of water, and gently agitating it, for thus they separate one from another, and do not any more represent a kind of thread, but are transported here and there by the movement of the water, without giving the least indication of life, or of spontaneous motion. Such are these bizarre little organic bodies, and whether they ought to be considered Animals, or Vegetables, as also whether they are a part of the Rust of the Leaves of the Beans, or are annexed to it by mere accident, I cannot determine, lacking many conclusive observations and not having been able to discover other similar complexes of the Rust, and of little threads on fresh Beans. Leaving then in doubt the nature of the described little bodies, I shall add that as the Bean is a very succulent plant, and its main canals are not so superficial, as those of Cereal Plants, the subcutaneous malady of the Rust, does not prove so dangerous to the Bean, and does not strangle its fruit in the milk. I have seen only that the Husks become a little more stunted.

On the leaves of Aquilegia, and on those of Stafilodendron, but only on the inferior part, I found on the day July 11 some rare tuftlets of the Rust, which with my Microscopes appeared to me very similar to that on the leaves of the Beans.

The Rust does not disdain even Plants of wretched odor, or of sharp taste, and it nestles also in these; thus in the inferior part of the leaves of the Peony, I found a large number of minute tufts,

disposed at a distance from each other, of a fine yellow, that present to the Microscope very pleasing Little Bodies oval in form (see Fig. 16), transparent in the color of Amber, not smooth, but troubled as a rule with hemispherical protuberances, and provided with slender, cylindrical, transparent little stalks, among which I have also found some tiny hairs, that to me appeared of a nature similar to those little hairs described above, and found among the Rust of the leaves of the Beans, composed of oblong Little Bodies.

On the same leaves of the Peony, intermixed with the tufts of the Rust, I observed another kind of Parasitic Plant, which as it first originates appears as a little hemispherical bubble, smooth, and shining, and is then gradually raised up, and grows perpendicular to the plane of the leaf, in the form of a hard, dark hair, large as a hair of the human Beard, and a little more than a line tall, but curved at the summit. One of the largest of these little hairs, appears under the Microscope (see Fig. 17) as a cylindrical body, smooth, transparent in the color of dark Amber in some places, and woven like a vase, or spacious receptacle full of an aqueous yellowish liquid which is seen clearly escaping outward in the form of droplets, upon pressing the hair between two layers of Crystal. The remoteness of my Garden of the Repose of the Aged, where once only I found on the leaves of the Peony this new kind of parasitic Plant, and my many Clinical occupations, have not permitted me to observe continuously the course of its Vegetation. It enchases, or nestles its roots within the vascular Parenchyma of the leaves of the Peony, and feeds itself on the sap prepared for it; hence it is not marvelous, if these leaves losing sap at the same time to the two gluttons, that is to say to this plant of the shape of a little hair, and to the Seventh kind of Rust, show upon themselves sick and dry Places. The day September 26 I succeeded in returning to my Garden, with the idea of better observing the above-mentioned Little Bodies, but I found the lobes of the leaves of the Peony, on the which they were borne, as dry as they could possibly be, and to me it did not appear that they had made any growth, from having been deprived in a certain manner of the proper nurse.

Also the Asclepiad, or Vincetoxicum, cultivated in the Royal Garden of Simples, the morning of the 16th of August I was fortunate in finding infected, on only the lower part of its leaves, with thick tufts of the Rust, of very vivid yellow color extending to golden, that at first raised the Cuticle in the form of a little pustule, or little button, and then caused it to crack, producing on the superior face of the leaf, certain large areas of yellow very near to being dried out. Their Fruits under the Microscope appeared similar to those of the Rust of the Peony, that is oval in form,

troubled by light hemispherical protuberances, and provided with a short cylindrical stalk, or stem, and rather coarse.

While examining a Spike of *Volpato* Wheat, the morning of June 16, at the House of Sig. Doctor Carlo Alfonso Guadagni, opening wide the Chaff or glumes of the little chambers, I found within certain little tassels of a Rust of the color of very bright gold, which I packaged up to observe it with the Microscope. This I saw at once was a mass of Little Bodies, transparent in a very pleasing Amber color (see Fig. 18), all of the same size, but smaller by half than the date-shaped Little Bodies of the first kind of Rust, usually borne on the stems, and on the leaves of the Wheat. They were likewise of a rather different form, that is globose, not smooth, but covered all over with little swellings or knobs, in a certain manner like the Comfits of Pistoia, or like the little globes of Seminal Powder on some tips of Flowers, or also like the Powder which escapes from diverse kinds of dry Puffballs, and because of such swellings, in certain lights they appear like Rosettes of Topaz. These swellings are not accidental in this eighth kind of Rust, for on all of the globules they are uniform, and crowded, and as the most acute Microscopes show, and the Solar also, there are about twelve swellings per globule, or a few more, depending on certain partitions, or membranous lacerations, that occur in the interior of each globule, which are not permitted to be shed uniformly from their skin, or surface. All of these globules are also full within of a yellow liquid like the date-shaped Little Bodies of the first kind, and this was easily comprehensible whenever the globules were pressed between two layers of Crystal under the Microscope. Here also one conjectures from their appearance, that the same globules as they grow old, or dry, diminish somewhat in bulk, wither in a certain manner, and show swellings more elevated, and in greater number (see Fig. 19). Although here no orifices are distinguished by which any liquid can penetrate inside, yet it is necessary to believe that they are present, since globules supplied with pure water, swell up a little, and successively in place of the superficial knobs, show (see Fig. 20) a globose projection in the middle, with a ring, or cracknel circular in outline. Very pure Oil of the Olive penetrated better, for after they had returned to the above-mentioned form of a globe surrounded by a rather low Cracknel, they continued to swell, and it reduced them to bladders round and completely full, and smooth, but little or not at all larger than they were in the form of knobby globules. Also these globules have something like little hooks on the surface, since they attach themselves to one another, and to other bodies that they touch, precisely as I have said happens with the date-shaped Little Bodies of the first kind of Rust. Only on

some few is there distinguishable any remnant of a little stalk, or little stem of the same color, and by analogy with other varieties that I shall record below, it can be conjectured, that these also are fruits of a tiny parasitic plant, sustained by very slender stalks, that arise from the radical placenta. The theory then of the organic vegetable body rests approved, as it has not been possible to uncover in these globules any, not even the least indication of life, or of animal motion, although almost everything was attempted to reveal it. The Illustrious Vallisnieri,[25] and Count Francesco Ginanni,[26] have seen, and described this eighth kind of Rust, which as far as I have seen, nestles solely in the internal part of the glumes, or Chaff, which inclose the *Volpati* grain; but the theory of these indeed very respectable Philosophers, does not combine with my Observations.

On the Wild Oat, which in certain years is able to infest the Fields of Wheat, I found on the day June 28 on the leaves alone but on both of their surfaces, scattered pustules of the Rust also of the eighth kind, of a beautiful orange color, its globules knobby, or like a Rosette, when crushed between two layers of Crystal under the Microscope, shedding a liquid of the same color, and besides the empty membranes of the little globules were distinguishable. The Spirit of Wine does not penetrate within them, and does not make them change shape; but the Oil of the Olive enters them easily and quickly, and reduces them first to hemispheres surrounded by a cracknel, after which they swell to the degree of becoming smooth vesicles not perfectly globose, but a little flattened on one side.

That kind of Dog's Grass named by Tournefort *Gramen spicatum vulgare secalinum*, on the day July 12 was on its leaves, and on the sheaths, all sprinkled with Rust of the same eighth kind, situated precisely as on the Grain.

Such also was the Rust, which on June 27 I found at Malavolta, upon both surfaces of the leaves only of the Wild Canary-seed, named by Tournefort *Gramen Spicatum, semine Miliaceo minore nigro*, except that the Rust Pustules were as long as on any plant up to now described, but even more delicate, and minute, because the little sap which the Canary-seed naturally has, does not permit them to make great progress.

Thus moreover was the Rust, of which I found a few tufts the day August 15, in the Royal Garden of Simples, on the leaves of the *Gramen spicatum spica cylindracea tenuissima longiore Inst. R. H. 520.*

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[25] Della curiosa origine degli Sviluppi.

[26] Delle Malattie del Grano in Erba Par. 2. cap. 11. § 8. p. 245 and Par. 3. cap. 3. § 9.

A kind of Sword-grass, or *Striancia*, named by Micheli *Cyperoides aquaticum maximum, foliis vix unciam latis etc. c. N. Pl. Gen. p. 57, n. 11.*, although its leaves are hard, and somewhat Cartilaginous, also was not able to escape the Rust, for on one rank-growing plant in the Garden of Simples of S. Maria Nuova, in the narrow Vascular and utricular tissues, which are framed between one nerve-like and somewhat woody fibre, and another, I found certain long rows of little oblong and crowded blisters, of dark color, of the Rust of the eighth kind, or at least so similar, that I could not find any difference, except that under the microscope some little fruits show the Rosette surrounded by a delicate transparent hem (see Fig. 21), that cannot be confused with others. The parts of the leaf above, corresponding to the places below affected by the Rust, show certain spots red in the center, and yellowed somewhat as if dried out over a large part of the interior.

The day July 8 in the Royal Garden of Simples I found a Plant of the Fenugreek, already dry, that had the Little Husks, and the stalks all spattered with very minute tufts of the Rust of the eighth kind, with some fine threads composed of series of very minute Little Bodies, on the order of those described above, found among the Rust of the leaves of the Bean; and the seeds of the Fenugreek within the little husks were quite meagre, and weakened.

Similar little tufts of the Rust of the eighth kind, I found on the same day, and on the day July 11, and on August 16, on the lower part only of the leaves of the Wild Trefoil, named *Trifolium pratense Flore monopetalo Inst. R. H.* and on both parts of the very delicate leaves of that kind of Medick, named by Tournefort *Melilotus Capsulis Rheni similbus, in Capitulum congestis*, but these tufts of very small size, because of the little sap which they had been able to steal from the plant, had caused the leaves to dry up. Some of the little globes of this Rust formed in a Rosette, showed some remainder of a little thread, or little stalk, and to me it appeared also that these threads bound the little globes together in the form of little bunches of grapes; and likewise upon some of their tufts, I seemed to discover some filaments similar to those on the leaves of the Bean, composed of Little Bodies of another nature; but the very smallness of these tufts, and the dryness of the plants on which they were borne, would not permit me easily to ascertain the truth.

On the said day August 16, in the same Royal Garden of Simples, I found covered by similar very minute dark tufts of the Rust, the leaves of the *Medica maior erectior, floribus violaceis*, called by the French *Luserne*, and I found it also on the upper part only

of the leaves, and on the stems of the *Lathyrus sylvestris luteus, foliis Viciae Inst. R. H. 393.*

A little earlier at p. 259 (26) I described the second kind of Rust, found on the lower part only of the Leaves of the common Rose, or *Rosa rubello flore maiore multiplicato, sive pleno, incarnata vulgo I. B.2. 36.*, and of the Carnelian Rose. Intermixed with this I found in rather large numbers the little tufts of the Rust of the eighth kind, very small by reason of the little sap, which they were able to steal from the scanty vascular parenchyma, among the anastomosing lateral and secondary nerves of these meagre leaves. These are of a very vivid gold color, tending to the color of flesh, and after they have ruptured the cuticle of the leaf, they appear as little tassels, a little hollowed at the summit, and they spread outward like little wisps of cotton. The globules of this eighth kind of Rust, observed the day June 28 with the number one Lens of the Microscope of the Francis Watkins, appeared formed in Rosettes, transparent in the color of clear amber, and some crushed between two layers of Crystal, appeared Sphaeroid surrounded by a Cracknel, and divided within into more cavities, and showed attached some remnants of a little stalk, or little stem slender and cylindrical. In the superior part of the leaf, corresponding to the tufts of the Rust, circular yellowish spots are seen, and all the remainder of the leaf shows injury and a nearness to being dried up. On the day August 16 I found very much of this Rust on the Rose Bushes of the Royal Garden of Simples, fresh and rank [in growth], which had sprouted there during the few days preceding.

Alike in all and for all to this Rust of the Rose Bush, is that which on the day September 25 I found in great amount, on the lower part only of the leaves of the ordinary Willow of yellow bark, distributed in very small bursts, to which above a little yellow spot corresponded. In the same leaves where the Rust was, and also in others where it was not, there were evident on both surfaces certain little spots like spatterings of dark rose, surrounded by dried yellow, and the leaves most stricken with these spots, had all become yellow. I could not say, however, whether such spots appertained to the Rust, or some other different malady of the Willow.

On the thin leaves of the Yellow Flowering Rose, planted in the Garden of the House of Sig. Ferdinando Morozzi in Pinti, on the day July 16 I observed on the lower part certain little spots, like points of Oil, which under the microscope appeared to me like little bursts of the Rust, either being born, or that had not grown, more, because of the little sap which they could steal from these meagre leaves, and for which above, there were corresponding pale spots, and even until the day September 25 they did not appear to have increased any

into bursts, such as I found in my Garden of the Repose of the Aged.

In the lower part only of the leaves of *Quinquefolium minus, erectum, incanum, et tomentosum, foliis tenuiter divisis, superne viridibus, flore parvo, petalis obtusis* of Micheli, there was intermixed among the fine hairs a great quantity of tufts of the Rust of the Eighth Kind, as it appeared to me, of a very vivid color between yellow and scarlet, also more charged than those of the Rose, that showed cylindrical remains of slender little stalks, or stems, attached to the little globes, which form a Rosette, but supplied with a little water, swell greatly, and become rather smooth. While they are in their usual form of a Rosette on the Isinglass of the Microscope, if exposed to the rays of the Sun, they produce a vague refraction of the rays, precisely as does the true Rosette of the shining Topaz. On three other kinds of erect Cinquefoil, in the Royal Garden of Simples, I found on the same July 11, and on the day August 16, such little bursts of Rust on the lower parts of the leaves, but of dark color, like those on the leaves of the Bean, corresponding to which on the superior surfaces of the leaves were little spots appearing as if dry.

In making observations on the Rust, it was helpful to me that in the two years past, between Spring and Summer, a great number of *Viuoli* plants were failing on a belvedere, from a disease similar to the Rust; although I searched for it this year 1766, I did not succeed in finding any, except on a small vine of the kind called Rose of Holland, in the Garden of Sig. Senator Serristori on the Renai, and this was on the morning of July 11. Then I was assured, that also this murdering Disease of the *Viuoli*, consisted of little tufts of the Rust of the eighth kind, that grew within the parenchyma of both surfaces of the leaves, and by their growth caused the cuticle to split lengthwise, opening a fissure, out of which issue little globules of dark color formed as a Rosette, and comparable with those of the Cinquefoil, with manifest little stalks, and little stems, uncovering meantime a dry area in the interior of the leaf where the Rust nestled, that quickly spreads to the remainder; but the cuticle torn from the leaf, appears under the Microscope as a very gay weaving of tiny vesicles. Also, among the Rust of the *Viuolo* I found pieces of little threads, composed of oblong, very minute little bodies, like those among the Rust on the leaves of the Bean.

Not only does this eighth kind of Rust delight in nestling in juicy or sweet, or insipid Plants, and feeding on them, but it covets also Plants with juices laden with sulfurous odors, and aromatic. Such is the common Tanacetum, on the superior part of the leaves of which, especially on the midrib, the day July 11 I found some rare dark-colored tufts of the Rust.

I found many more of them, mostly on the day August 16, on the bitter, hard and old leaves of the Tansy, or *Erba Santa Maria*, both on the upper, and on the lower sides, and on the stems also, with areas of dryness in the interior. The little globes of both these kinds of Rust make Rosettes, and turning the Isinglass of the Microscope to the sun, cause a very vague refraction, of the rays like that made by the Rosette of the brilliant Topaz. Among the dry tufts on the *Erba Santa Maria*, I found a certain few of those hairs, that are an aggregation of very minute and oblong little bodies, like those that occurred in the Rust of the leaves of the Bean.

Also on the lower part of the leaves of the aquatic, sharp-tasting Persicaria, cultivated in water in a vase at the Royal Garden of Simples, I found on the day July 11, and on the day August 16, many rank little bursts of dark color of the Rust of the eighth kind, with little globes in Rosettes, transparent in the color of dark Amber, that presented to the Sun caused also a vague refraction of the rays. Several of them retained their little cylindrical stems, and not a few appeared in the form of little globes, surrounded by a globose cracknel. On the upper part of the leaf, corresponding with the Tufts of the Rust, appeared certain circular spots of the color *xerampelino*, which is the color assumed by the leaves of wild Grapes at the first frost.

It is the more wonderful, that this eighth kind of Rust is so eager to nourish itself also on the sap of Plants by their nature caustic, and venomous, such as the Tithymals. In fact on the day July 11, and the day August 16, in the Royal Garden of Simples, I found several tufts of the color of Amber, on both faces but in the middle only, of the leaves of the *Tithymalus maritimus glauco folio Mich. H. Flor.*, and there these leaves became yellow, and began to fall. On *Tithymalus repens, folio Esulae minoris Dodonaei, glauco tamen, et elatior Triumf.* the orange-colored tufts of the Rust were only on the lower parts of the leaves, which in their upper part were precisely of the green color, which is believed healthy, but in the remainder they were yellow, and very near to being dried up. Both surfaces of the fetid leaves of the Pod Tithymal of the Cesalpino, were infected with Little Tufts of yellow Rust, while the reverse side of the leaf showed the natural green, with the middle becoming yellow, and tending to dry up. On two other leaves, I observed certain little spots of a filthy blood color, that pass from one surface of the leaf to the other, concerning which I cannot say whether they belong to the same kind of Rust, not well developed, or are some kind of August dew, or other malady of the Plant, be-because I found many more similar and also larger spots, on the leaves of several other kinds of Tithymal, cultivated in the Royal

Garden of Simples. Finally both surfaces of the very small leaves of the Tithymal No. 27 of the Michelian Catalogue, which is the *Spinoso del Montzelio*, were spattered with very tiny, and scarcely visible reddish pustules of a Rust, concerning which I have not been able to ascertain whether it is of this same eighth kind, or not.

The Ninth kind of Rust is one, which has globose fruits, that under the Microscope present a kind of Rosette in the middle (see Fig. 22), more copiously supplied with little knobs, that is from eleven to thirteen, and more minute than in the eighth kind. This Rosette then is surrounded by a vast circular smooth Cracknel, which is the strongly curved surface of the little globe, continuous with the out-jutting Rosette. Thus to me appeared on the morning of August 13, with the Microscopes of Sig. Doctor Guadagni, the little globes transparent in the color of oharged Amber, which I had found on the day July 11, in the Rust which infested the lower part only of the leaves of the Lime Mint, and three other kinds of Mints, cultivated in vases in the Royal Garden of Simples, and in that of S. Maria Nuova. This Rust was distributed in very small bursts, or tufts of dark, or blackish color, that had broken the cuticle of the leaf, and caused it to crack in the form of a scale, and on the upper side had produced little dry, somewhat scorched areas. On other leaves, on the same Plant, were observed certain dark red and filthy little spots, on the order of those noted above on Willow, and the Tithymals.

For the tenth kind of Rust, I shall record one that I found on the day July 8, in the form of little dark red spots, spattered on the lower parts only of the leaves of the Fustic, named by Botanists *Cotinus Coriaria*, cultivated in the Royal Garden of Simples. This being placed fresh under the Microscope, showed a uniform material, similar to an Unguent, with some advertisement of little globes. When reexamined dry on the day August 13, there were clearly to be seen certain small globose fruits (see Fig. 23), the doubles of those of the eighth kind, roughened over all the surface by a great number of little knobs, and the greater part of them showed a remnant of stem, or somewhat enlarged little stalk.

The day November 6 it being my good fortune to be able to go for a short time to my Garden of the Repose of the Aged, to make a sowing of various kinds of Wheat, by the method of Abbot Pizzichi, I observed there the following kinds of Rusts, as they appeared to me with only my own Microscopes.

In the lower parts then of the leaves of the yellow Peach Tree, I found certain very minute, and dot-like tufts of a dark-colored Rust, which with the Microscope showed round little globules, with little stems, very similar to those of the Rust of the Fustic

described a little earlier; and the superior parts of the leaves corresponding to the tufts of the Rust, were spotted with red or were somewhat dried out.

Similar little tufts of Rust, but more dense, were on both surfaces of the leaves of our ordinary Willow, that is *Salix sativa lutea, folio crenato Inst. R. H.*, in which there were distinct rotund little globules, on the order of those of the eighth kind. Internal to these tufts, and on the part of the leaf opposite to them, dark, dry spots were present.

Comparable in all and for all to that of the Willow, is the Rust which I found on the lower parts only of the leaves of the Mulberry Tree; except that these leaves were already yellow from Frost, and some were all spattered with little spots, and little dry, dark places, but without tufts of Rust upon them, and some such spots, had in the center, a little dry, whitish place.

The leaves of the Vine, also yellowed by the Frost, were all spattered above with little blackish spots, and corresponding to them below were certain dot-like, dark bursts, which appeared to me like very minute tufts of Rust; and such spots also are called Rust by the Countrymen; but I could not ascertain whether they were the same, that Pliny called *Scabies*.

Likewise certain leaves of the *Podagraria*, or *Angelica Sylvestris minor, sive erratica Inst. R. H.* yellowed by disease, were spattered on both surfaces with little dry spots, with rare tufts of Rust like those of the Vine.

All the kinds, or varieties of Rust enumerated so far, and many others like them, that I have not seen, form a Section, or Family, of Microscopical Parasitic intercutaneous Plants, that is to say that are borne solely and grow beneath the cuticle, and within the cortical and medular substance of diverse Plants of rather large mass. There remain certain others, of which I am not truly assured whether they ought to be ascribed to this same Family, or whether they constitute two others different and distinct. Certainly I see in them the globular fruits, on the order of those of the Rusts, and I see the radical tufts incarnate in the substance of other Plants; but the Vegetation, or so to speak, ramification, is notably diversified, except that not being dependent on having it, I have seen it also not well matured, and perfected. Returning then to the most decisive Observations that others have been able to make, for the present I place them among the Rusts.

The day August 16, in the Royal Garden of Simples, I found on the upper parts of the leaves of certain plants of the common Briar, many little spots similar to a spattering of droplets of water, blood red, but in the middle, or center, somewhat dried up, and empty.

These spots extended to the under part of the leaves, and there they appeared outlined by a filthy color, but from their centers little hemispherical knobs of Rust spread outward, smaller than half of a kernel of Panicum, whitish, and under the Microscope appearing to be an aggregation of innumerable and minute little globose bodies, that is to say fruits like those of the Rust. As with only my own Microscopes I was unable to arrive at a clear understanding of these, I profited on the morning of October 19 from the kindness of Sig. Doctor Carlo Alfonso Guadagni, and with his microscopes I saw without equivocation, that these tufts of rust smaller than those of the Wheat, and of the Rose, arose from the parenchyma, and were inserted among the thick hairs of the leaves, and were at the apex loaded with very many little globes. These little globes placed upon the Isinglass of the microscope, and separated with a droplet of water, appeared in a certain manner like the Fruits of the Raspberry, that is to say little balloons all covered over with little swellings (see Fig. 24) and slight hairs. Their shape approached close to that of the powder of the Apexes of the Mallow, or even more to that of the black powder, which soars up from the dry Plant of the Puffball, or *Lycoperdon,* except that the globules of the Puffball are a little smaller, and have slight hairs that are somewhat longer. The globules of the Rust of the Briar, undoubtedly have attached to them a short little stalk, or little stem, and are a little bit larger, than those of the eighth kind of Rust, transparent and pale, like the ordinary drinking glass, but in their transparency showing within a fullness not uniform, and with smoky lines of shadow, and somewhat of a division into irregular little cells. Pressing them between two layers of Crystal, and setting them under the Microscope, made clearly recognizable the origin of this smokiness and the appearance of cellules, since very many of them being by good fortune broken off, and torn, poured out great numbers of very minute little bodies (see Fig. 25) having the shape of a Seed of the Date, with a very delicate membrane, and transparent as water, wherever the Shells of the Globules were a little suffused with paleness. These little bodies were not droplets of liquid, but absolutely organic Bodies, that is to say seeds of this kind of Rust, all of the same shape and size, a little stuck together on the surface, since they were attached to each other, but the water easily separated them. It was not possible to ascertain how many little bodies stood inclosed in each Little Globe, but certainly many of them were seen moving out of the shells broken, and torn by the pressure of the two sheets of Crystal, and it was clearly seen, that there were others within the hollow of the shells. This astonishing phenomenon has caused me to wonder more, whether also the little bodies that I said I observed

united to the Rust of the sixth kind found on the leaves of the Bean, could issue from the Fruits of that Rust?; but having no more fresh Plants, and the Sig. Doctor Guadagni being obliged to return to Pisa, it was not permitted me to be able to ascertain the truth of the matter. Assuming that the smallness of the tufts of such a kind of Rust, ought to be believed natural, and constant, then I found such on the leaves of the Briars in a hedge in my Garden for the Repose of the Aged on the day September 26, and also November 6, except that some tufts were whitish, and others blood colored, but in these were clearly distinct with the Microscope certain slender little stems, or little stalks, sustaining very minute little globes.

On the same day, August 16, on the lower parts of the leaves of *Epimedium Dod.*, cultivated in a Vase in the Royal Garden of Simples, I found several minute whitish bursts, but so tiny, that I could not determine their character specifically. On the upper side the leaves had certain pallid spots tending to dryness, in places precisely that corresponded to the tufts of the Rust.

Thus moreover was the Rust, which the same day and place I observed on the leaves of the *Sium, Sive Apium palustre, foliis oblongis Inst. R. H.*

The twelfth kind will be certain material, which spoils the Silique of the Roman Bean, that was sent to me by the Paterno at Valambrosa on August 22. These pods were strongly spattered on both sides with round spots, as large as a Lentil, the color of deep blood, hollowed like a porringer, or like the Pockmarks of Smallpox toward the axis of the Silique (see Fig. 26) and with the extreme circumference a little raised. Such spoilage penetrated through all the substance of the subjected Valve or half of the Silique, and where it occurred, caused the Silique to twist awry, and dry it appeared of a blackish color. In the middle of the bowl formed by such a spot, there extends upward a tuft, or knot of material delicate as the *Puccinia* of Micheli, but divided into many bursts, and in sinuosity irregular as certain kinds of Sponges, and the crustaceous Alcyonaria (see Fig. 27.), in color between yellow and flesh. These tufts, whether fresh, or dry, scraped with diligence, placed on the Isinglass of my Microscope, and freed with a droplet of water, separated entirely into numerous little oval transparent whitish bodies, of an astonishing smallness, and even smaller than the globules of the Milk of the Wheat. These moreover the morning of the same October 19, reexamined with the Microscope of Sig. Doctor Guadagni, appeared at first (see Fig. 28) transparent and pale, oblong, with two strictures, and three swellings, and similar in a certain manner to the Silique of the Ervum, or Pulse, but after a short time being well supplied with, and swollen by the absorption of water that was

furnished for their disgregation, they lost the advertised stricture, and became smooth (see Fig. 29) and like the Seeds of the Date.

On the upper surfaces of the leaves of the *Sanguine*, or *Cornus foemina Inst. R. H.* in my Garden of the Repose of the Aged, on the day September 16 I observed certain irregular spots having the color of Blood, that were also a little evident on the lower parts. Among these spots I noticed certain rather small raised, white points, of a rather hard material, such as Sugar would represent. These when examined on the morning of October 19 with the Microscopes of Sig. Doct. Guadagni, appeared to be very analogous to the kind of Rust on the Roman Kidney Bean described above, that is to say a tuft of irregular Form, all rough on the surface, which scraped with diligence, placed on the Isinglass of the Microscope, and dispersed with a droplet of water, did not show anything except very many little bodies extremely small, transparent, and having the shape of the Seeds of the Date. The day November 6 I again observed other leaves taken fresh from the same *Sanguine* Plant, and there I found that the Blood-colored spots were even more extensive and becoming black, and in the middle of them, on both the faces of the leaf, appeared little bleached spots limited in circumference, like the Crustaceous Lichens.

One not very different little plant, similar to the Lichens in its expansion, was found in the Garden, and on the day November 6, on old and yellow leaves of the white *Tartufo*, or *Corona Solis parvo flore, tuberosa radice Inst. R. H.* In the yellow parts of such leaves, there were dry places, in which both below, and above were to be seen certain little bleached spots, similar to those described on the *Sanguine*, but smaller, and somewhat puncticular, that projected a little above the dry surface of the leaf, and were more crowded in the middle. These then observed from above with my Microscopes, show a dense tuft with very many little heads or rotund fruits.

The leaves of the Linden, or *Tilia foemina, folio maiore Inst. R. H.* had on the day August 4 on the upper parts certain little spots, or bleached punctations, like a spattering of Sugar, attached strongly to the leaf, and buried in it, while all the rest was green and hale. The substance of these little spots, scraped with diligence on the Isinglass of the Microscopes of Sig. Doctor Guadagni, and supplied with a little water, appeared to be nothing other than an incredible number of very tiny transparent globules, and of certain little transparent bodies also, elongate in the form of a Silique and subdivided into four or five cavities (see Fig. 30). I am not certain whether such Little Plants ought to be recorded among

the Rusts; I see indeed that Ant. van Leeuwenhoek [27] says: *cum observarem materiam illam liquidam, quae ex superiori parte Foliorum Tiliarum protruditur, quamque Agricolae nostrates Rubiginem, sed falso, vocant;* but I am not certain whether he intended to speak of the bleached little spots I have described, which at first view resemble Manna. It may be added that on the lower part of the Leaves, he found an unspeakable number of very minute Insects of two sorts, which he described, and for which I searched in vain.

In the Royal Garden of Simples I observed on the day July 11 a very rank Plant of Tragopogon, on several of whose branches there were, here more, there less, incrustations of certain whitish, raised spots, like little casts of plaster of less dense tint. Some of these spots appeared like little drops of Manna, others as if they were the milky sap of the Tragopogon itself, but coagulated, especially on the internal part to the incision of the calyx of the Flowers. All those branches where there were such white spots, appeared withered, infirm, and very nearly dried up, while the others were hale and fresh. Examining on the day August 4 the white spots already dried up, I found them situated on the surface of the Plant, not buried in it except a very little, and raised up to form cavernous swellings. I noted that upon touching those little branches that were infected, there rose up a very fine white powder, which on the Isinglass of the Microscope appeared to be nothing other, than very minute little bodies of angular shape, tending towards cubical, and empty within. These I placed upon a droplet of water, and saw that very quickly they absorbed it, and became little smooth balloons, as if made of glass, transparent in the center, and blackish in the hem. Permitted thus to recover and swell as much as they could, they appeared as vesicles all crystaline (see Fig. 31), with very delicate skin, and larger than the globules of the *Volpe* of the Wheat which is described more fully below. Here I could not distinguish little stems, or attachments of any sort, as all the described white spots broke up into little vesicles, without showing anything else. I have no doubt, that this substance was of Vegetable nature, and a Parasitic Plant, although not buried so much in the Tragopogon, as the Rusts usually are in other Plants, for certainly it gains its food from the liquid properties of the Tragopogon, the stems of which are in texture very similar to those of Culmiferous Cereal Plants; hence it takes sap from and dries up those branchlets, and those leaves upon the which it manifests itself. Therefore I take the liberty of recording it as the tenth kind of Rust, without

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[27] Continuatio Arcanorum Naturae detectorum Epist. 104. p. 149.

having been able to observe it fresh upon any Plants, not even upon the Tragopogon, upon which, already dried up, on the day August 16 it was dispersed.

Having to pass to the description of other Microscopical Parasitic plants, which in this memorable Year 1766, were born and multiplied prodigiously, I believed it better to relate briefly all together, what has been written up to now concerning the nature of the Rust of the Wheat, and then reverently to submit below for the judgment of the Public what I think about it.

It is certain that the Rust is a very ancient Scourge of the greater part of the Country, cultivated by Mankind in the old World. It is known from the Holy Scriptures, that the Promised Land was not exempt from it, although very little dominated by Watery Meteors; and it is known from Theophrastus that Greece, and from Varro, Horace, and Virgil, that Italy were subjected to it, although more afflicted by Rain, Clouds, and irregular Winds. A more ancient testimonial that the Rust usually caused great waste in the Fields of Tuscany, and Rome is the giving of the *Feste Rubigali*, which the King Numa, according to legend, desired be solemnized each year on the day April 25 by his Subjects, to placate the ire of the Goddess *Rubigine*, or *Robigine*, in imitation, of the at that time very powerfully confined Etruscans.[28]

The Ancient Writers on Botany, and Agriculture, were ignorant of the true nature of the Rust, but nevertheless they noted punctiliously some Phenomena and effects. Theophrastus the Heretic treated of the Maladies of Plants,[29] saying that these, precisely as in Animals, attain their first origin from causes either external, or internal; and on this cause depends the failure of the Plant either entirely, or in part, to fructify. Plants fall sick from external causes, as when they are affected by Cold, or by excessive Heat, or by long and driving Rains, or by other irregularities, and inclemencies of the Air. All such Maladies, as arise in Plants from the fault of the Air, make greater impression upon the more debilitated plants, as when they are in bud, and beginning to germinate, and when they are weakened by the setting of Fruit. Of such Maladies, Theophrastus says, that they are common to all Plants, as is the Rust, which damages the grains more than any others, and the Legumes only a little less. Among the Grains, Wheat, and Rye, suffer most of all

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[28] See Rosini Antiquit. Romanar. cum Dempstero L. 2. c. 20. Ovid. Fastor. L. 4. v. 907. Plinii Hist. Nat. L. 18. c. 29. p. 491. Monf. Gio. Batista Passeri presso il Ginanni delle Malattie del Grano in Erba p. 22. n. 36.

[29] Hist. Plant. L. 8. cap. 10. de Causis Plant. L. 3. cap. 27. L. 4. cap. 15. & L. 5. cap. 9.

from the Rust; the first because it has a naked kernel; the other because it is covered by many tunics, but has the last leaf, or sheath of the spike, very near to the spike, and therefore retains the putrefying humidity, which generates the Rust. Hence, Theophrastus goes on to say, those among the Grain Plants are exempt from this misfortune, that have the apex curved, that is to say somewhat bent toward the ground, not upright, and bold because thus rain water falling on them runs off better, and cannot then remain and draw down the Dew. This curvature, says Theophrastus, succeeds more readily with long spikes, for those that are short and thick, as are the tame ones, that is to say those that are ordered in three parts, stand erect, and therefore are more easily attacked by the Rust. It is helpful too when the spike is a long distance from the last vaginal leaf, because the humidity producing the Rust, nestles in the leaves more than elsewhere; and this, according to Theophrastus, is the reason why a kind of Rye called by the Greeks *Achilleis*,[30] more black than white, with erect spikes, becomes rusty; whereas another called *Etheocrithum*, stays immune, as it has the spike bent toward the ground. The false idea of putrid humidity producing the Rust, has given cause to Theophrastus for conjecturing, that the nearness of the vaginal leaf, and the erect position of the spike, render the Wheats and the Oats more subject to the impression of the Rust. Thus it happens in truth, but it happens because the Wheat and the Oats while having the spike erect, and near the last leaf, are too tender and young, and have their Fruit in Flower, and in Milk, and therefore ought to have continuous and abundant food, of which the Rust robs them, if it becomes manifest at such a critical time. On the contrary when the Wheat and the Oats are well nourished, and their grains mature, and the last little internode of the stem has grown as it ought, and rises much above the vaginal leaf, and the spikes have become heavy, they are forced to bend toward the ground. Then the grains have little or nothing to fear, no matter how much harmful humidity falls on the leaves, and on the spikes. Among the Legumes, notes Theophrastus, the Bean suffers from the Rust more than the others, as well because it has more leaves, and is seeded on low ground; as because there is much sap, and it sucks up much humidity; and he adds, that as it carries its fruit closer to the ground, especially the lower ones putrefy, because they are less ventilated. The Pease likewise is a very fragile Legume, and suffers much from the Rust, because it is low, loaded with leaves, makes large branches, and spreads widely. I do not know truly whether the Rust causes great damage to the Pease, and in the year passed,

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[30] See Io. Bod. a Stapel in Theophr. Hist. Plant. L. 8. cap. 4. p. 934.

I could not find it; although there was much on the Bean, as I noted, but with little prejudice to the Harvest.

Concerning the causes that produce the Rust, the opinions of the Ancients were somewhat diverse, and all of them stressed as causes the circumstances concomitant with the true production of the Rust. Theophrastus [31] writes: *Rubigo autem putredo quaedam residentis humoris est: quamobrem si copiosae Pluviae fuerint, Rubigo nulla consistit, diluitur enim atque detergitur; sed si stillicidia vel etiam Rores incesserint, Solque sequutus sit, flatusque desit, nimirum putrent. Quapropter locis editis, commodeque perflatis, minue Rubigo creatur: cavis Rorulentisque magis, et Pleniluniis, quoniam Lunae quoque caliditas putredinem auget, et omnino aer humidior.* Also Aristotle writes:[32] *Rubigo per humorem calidum, alienumque consistere solet.* Ovid [33] has left an elegant paraphrase of the Prayer, which the Flamens made each year to the Goddess Rubigine, in name of the Public, at the *Feste Rubigali*, which is consecrated to this Goddess in the wood, a little outside the Porta Catularia of Rome, and celebrated on the day April 25, which was reputed to be the middle precisely of Spring, *quoniam* says Pliny [34] *tunc fere Segetes Rubigo occupat.*

Aspera Rubigo, pareas Cerealibus Herbis,
Et tremat in summa lene cacumen humo,
Tu fata Syderibus Coeli nutrita fecundis
Crescere, dum fiant Falcibus apta, finas.
Vis tua non levis est, quae Tu Frumenta notasti,
Moestus in amissis illa Colonus habet:
Nec Venti tantum Cereri nocuere, nec Imbres
Nec sic marmoreo pallet adusta Gelu,
Quantum si culmos Titan incalfacit udos:
Tunc locus est irae, Diva timenda, tuae
Parce, precor, scabrasque manus a messibus aufer,
Neve noce cultis, posse nocere sat est;
Nec teneras Segetes, sed durum amplectere Ferrum,
Quodque potest alios perdere, perde prior.[34a]

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[31] De causis Plant. L. 4. cap. 15.

[32] Problem, fest. 26. Probl. 19.

[33] Fastor. L. 4. v. 908.

[34] Hist. Nat. L. 18. c. 26.

[34a] Corroding Rubigo, do thou spare the blade of the corn, and let the smooth top quiver on the surface of the ground. Do thou permit the drops nourished by the favoring seasons of the heavens, to grow apace until they are ready for the sickle. Thy power is not harmless in its exercise. The grain which thou hast marked as thy own, the sorrowing husbandman reckons in the number of the lost. Not so

Pliny wrote [35] *Coeleste Frugum, Vinearumque malum, nullo minus noxium, est Rubigo. Frequentissima haec in roscido tractu, Convallibusque ac perflatum non habentibus: diverso carent ea ventosa, et excelsa—Plerique dixere Rorem inustum Sole acri, Frugibus Rubiginis causam esse, et Carbunculi Vitibus, quod ex parte falsum arbitror, omnemque Uredinem frigore tantum, innoxio constare.*[36] *Id manifestum fiet attendentibus; nam primum omnium non hoc evenire nisi noctibus, et ante Solis ardorem, depraehenditur, totumque Lunari ratione constat; quoniam talis iniuria non fit nisi Interlunio, Plenave Luna, hoc est praevalente, utroque enim habitu plena est; sed Interlunio omne lumen quod a Sole accepit, Coelo regerit. Differentia utriusque habitus magna, sed manifesta; namque Interlunio Aestate calidissima est, Hyeme gelida e contrario in Plenilunio Aestate gelidas facit noctes, Hyeme tepidas. Causa evidens, sed alia redditur a Fabiano, Grecisque Auctoribus; Aestate enim Interlunio necesse est cum Sole nobis proximo circulo currat, igne eius cominus recepto candens; eademque Interlunio absit Hyeme, quando abscedit et Sol. Item Plenilunio aestivo procul abeat adversa Soli; Hyeme autem ad nos per aestivum circulum accedat. Ergo per se roscida, quoties alget, infinitum quantum illo tempore cadentes Pruinas congelat.* Also Plutarch briefly writes:[37] *Rubigo humescentia occupat semina;* and Berizio [38] was of the opinion, that the Rust falls from the air, when he said: *Simul ac videris Rubiginem in aere congregari.*[39]

Modern people have not been more fortunate, in discovering the true nature of the Rust, and they also have stressed as causes the circumstances, which accompany the appearance of the Rust. P. Eusebio Nieremberg [40] wrote, that in *Frugibus ex serenitatibus,*

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injurious to the corn are the winds or the showers; nor is it so pallid when consumed by the frost, rigid as marble, as when with his warmth, the sun makes hot the moistened stalks; in such case, dread Goddess, is thy wrath exercised. Spare I pray thee, and keep thy rough hands from the crops; injure not our fields; to possess the power of inflicting injury is enough; seize not in thy embrace the tender crops, but rather the hard iron, and do thou first destroy that which has the power of destroying others.—From Riley, Henry T. The Fasti, Tristia, Pontic Epistles, Ibis & Halieticon of Ovid Literally Translated into English Prose. George Bell & Sons. London. 1909.

[35] *Ibid.* c. 17 & 28.

[36] See the Critique of this opinion of Pliny by Count Ginanni in the Malattie del Grano in Erba Par. 3. cap. 1. p. 300. n. 324.

[37] Natural. Quest. p. 419.

[38] In Geoponicis Graec. L. 5. c. 31.

[39] See Ginanni delle Malattie del Grano in Erba Par. 3. cap. 1 § 1. p. 283.

[40] Hist. Nat. L. 6. cap. 22.

Flatibus Austrinis, aqua et Rore in Spicis infidente, quibus ex Sole fervefactis Aerugo [Rubigo] creatur. Tanara [41] was of opinion, that the humidity of certain plump, and viscous Fogs, after having fallen or having been dried by the Winds, being dried upon the Spikes by the Sun, and upon the Chaff, became attached there, and were converted into malignant material. To this purpose Count Francesco Gianini observed;[42] *Whenever Winds from the South cause the Oats to burn, I have never observed here (in Ravenna) any water, or Dew upon the Spikes and the stalks of the Wheat; thus to me it is evident, that the vapors carried by the Wind were so much died out and little viscous, that their humidity did not appear;* but I do not believe that this is verified entirely in Tuscany, where the Winds from the South are very humid. Chambers [43] attributes a kind of rust *to the falling of the Dew, or the Rain, immediately followed by the penetrating rays of the Sun that suddenly seal shut the dilated pores, and burn the Leaves.*

To certain showers that fall in the Summer, others have attributed the origin of the Rust, as Luca Scroeckio notes,[44] saying: *Pluviam quae dum Sol splendet, delabitur, non semper, aut raro Rubiginem producere existimo, quod etiam experientia testatur: Vegetabilium tamen familiae eamdem quandoque fieri nocivam non dubito, si a radiis Solaribus tenera eorum aliquorum corpuscula flaccescere prius contigerit, unde nimirum guttulae aquae ubi super ea depluerunt, ab eorumdem radiorum calore excalefactae, fibras tenuiores quasi excoquere, et destruere, succique contenti motum sufflaminare valeant.* Antonio Vallisnieri [45] says, *that the rust came to be believed to be born of certain Fogs of poisonous Nature, and of certain short Rains in the great Heat of the Summer, after which the cooking rays of the Sun suddenly succeed.* Pier Crescenzio attributed to similar Rains the origin also of the *Melata* [Mildew?], that infests the Vine, and wrote:[46] *accidit etiam saepissime, ut ut tempore caloris descendat cum Sole parva Pluvia venenosa, et adusta, quae vulgariter apud Bononienses Melumen vocatur, quae multa genera Vitium adeo laedit, ut earum fructum in nihilum omnino reducat; ideoque ubi*

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[41] See Ginanni Par. 3. cap. 1. p. 294. n. 318.

[42] Delle Malattie del Grano in Erba Par. 3. c. 1.

[43] See Ginanni Par. 3. cap. 1 § 4. n. 312. p. 389.

[44] In Scholio ad Observ. 93. Dec. 3. A. 9. & 10. Ephemer Acad. Naturae Curiosorum.

[45] Saggio d'Istoria Medica e Naturale nel T. 3, di tutte le Opere p. 451.

[46] De Agricultura L. 3. cap. 17. p. 168.

haec frequenter accidit, ea plantentur genera Vitium, quae modicum aut nihil laeduntur ab eo, ut est Malitia, et Albana, et Grilla, et quaedam alia genera nota. Count Ginanni [47] explains this passage from Crescenzio, and another from Hales [48] as the Carbunculation, or *Uredino* of the Ancients, not indeed as the Rust, with the theory that very minute drops of water of globular shape, in the guise of Lenses or small beads of Crystal, cause the rays of the Sun to be refracted and become converged, scorching the surfaces of the Plants, that correspond to the Focus, or point of coincidence of these rays.[49] This theory, which was set forth by our immortal Galileo,[50] has been both cast aside, and sustained by others, as many diligent Observers have noted a graceful inverted Rainbow, which is depicted in the globose droplets of Dew, suspended in the Grass of the Wheat.[51]

Others have thought, that Dews, or Fogs with salty and caustic qualities, are the cause of the Rust. The first to declare this Opinion, was the Celebrated Bernardino Ramazzini, who said:[52] *Generari utique Rubiginem ex Rore, serenis noctibus, cum Ros non decidat nisi sereno Carlo, et silente Luna, veritati valde congruum videtur, nam revera sub initium Iumii, prope Interlunium, signa Rubiginis observari coepta in Frugibus, et Plantarum foliis, quae parvis maculis nigricantibus distincta, Puncticulari morbo laborare videbantur: argumentum evidens eiusmodi stygmata a Roris guttulis, ubi diu haeserant, fuisse inusta—Hae sunt nativae dotes Matutinis Roris, ac praesertim Maialis, in salubri tamen Constitutione, ac solo minime uliginoso, nec palustri: at si ex malis Temporum constitutionibus, et noxiis afflatibus, seu pravis e terra exalationibus Ros vitietur, in Rubiginem degenerat, malum quo nullum noxius est, et cui, ut ait Plinius, non comparantur Grandines, neque Procellae, quae numquam Annonae intulere caritatem. Gigni Rubiginem itaque e Rore existimo, dum multa nitrosa et acida corpuscula e solo elata, et per aerem undequaque dispersa, salinis particulis, quibus naturaliter Ros abundat, sociantur, quae simul in magno Aeris Receptaculo fermentata et exaltata, modo nobis*

[47] Delle Malattie del Grano in Erbe Par. 3. cap. 1. p. 296.

[48] Statique des Veget. CapŒ 1. Exp. 9.

[49] See Ginanni delle Malattie del Grano in Erba Par. 3. cap. 1 § 3. n. 307. p. 286.

[50] See his work in the Florentine Edition Tom. 2. Problemi sciolti Probl. 7. p. 52.

[51] See Ginanni Par. 2. cap. 12 § 11. p. 259.

[52] De constitutione Anni 1690 ac de Rurali Epidemia, quae Mutinensis Agri, et vicinarum regionum Colono graviter afflixit, Dissertatio, ubi quoque Rubiginis natura disquiritur, quae fruges et fructus vitiando, aliquam caritatu Annonae intulit p. 29, et. seq.

imperceptibili, in liquorem coeant, qui postea sub forma Roris deciduus, et Plantis inhaerens, easdem maculis diversi coloris sugillet, uti apud nos factum his duobus annis 1680. et 1689. cum in priori Plantae omnes, et fructus rubris veluti Peticulis, hoc anno vero nigris laborare viderentur. Praepollere itaque in Rubigine acrimoniam acidam, et corrosivam, haud absimilem Aquis Stigiis, et Spiritibus Nitri et Vitrioli, longe verisimilius, quam Alchalinam ex Sale acri et Caustico, quando nulla causa animo fingi possit, quae in tam remissis caloribus huius Constitutionis, ustionem et acredinem accersere potuerit. Messrs. Cook and Mortimer [53] lean towards the Rust *being a thick and viscous vapor, exhaled in the Spring, and in the Summer by the Plants, and by buds, and even by the Soil itself, in times entirely quiet, when there is neither sufficient Sun to draw it up, nor sufficient Wind to disperse it, while the cold of the evening advances, and it is condensed, and falls on the Plants, and with its thick and viscous substance, stops up the pores, and thus impedes the Transpiration.* Count Gianini [54] explains how the Dew can acquire its caustic and corrosive nature, and with this produce, as he believes, the Rust. In accord with the opinion of Ramazzini P. F. Fortunato de Felici,[55] and M. Deslandes [56] said of this: *dans quel cunes de nos Provinces, quand les annèes sont trop pluvieuses, et qu'il tombe souvent de cette espece de Brouillard gras, que les Laboureurs, et les Iardinieres nomment Nielle, tous les Grains degenerant.* To a determined kind of Dew, and signally to the August Dew, Gio. Gristof. Fromanno [57] believes that the production of the Rust ought to be referred. *Ros Mellitus*, he says, *cruda plurima in se continet, et Vaporem incoctum, qui proinde adhaerens Oleribus, plantis, arborum foliis, et Graminibus, ea facile corrumpit, abitque in virus, quod quidem dulcedine Pecudibus imponit; et calore urgente, Rubiginem Satis adfert, cum destituatur humido alibili, variisque interdum ludat figuris in fructibus et foliis.* Fromanno adds one fact, which if it had been well ascertained, would provide great cause for speculation: it is that in the Year 1663, in certain places the Rust in the Fields appeared of a yellow color,

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[53] See Ginanni Par. 3. cap. 1. p. 290. n. 313.

[54] *Ibid.* § 6. p. 291.

[55] In Adnot. ad Io. Arbuthnot Specimen effectum Aeris in Humano Corpore Cap. I. p. 38. n. 65.

[56] Obs. nouv. & phys. sur la maniere de conserver les Grains.

[57] *De Verminoso in Ovibus et Iuvencis reperto Hepate, in Actis Acad. Nat. Curios. A. 1670. Obser. 188. p. 252.*

but in the Pools of Water it was black in color. Also Luca Scroeckio [58] concurred with the opinion of those referring the production of the Rust, to a particular kind of Dew, saying: *Rubiginem esse vaporem aereum crassum et pingue, frigore nocturno circa folia, flores, ramosque arborum concretum, sive etiam cum Pluvia tenui, dum Sol splendet, depluente, illuc delatum, plurimorum fert opinio.* Subsequently he referred to the opinion of those who believe that the Rust is caused by certain small Insects, and after having confuted this, added: *quod exhalantes quandoque ex terrae gremio acres et nocivae particulae, frigore nocturno iterum se condensare, versus Terram relabi, herbisque incumbere queant, nil obstare credo, quod vel observatus quandoque Nebularum crassarum faetor fatis arguit licet ex ipsis etiam Vegetabilium poris turgens in ipsis succus exsudare, et Rubiginem talem sistere possit.* All this proves solely, that the Rust manifests itself, that is to say, grows promptly in the Constitution of the air described by these Authors, but does not prove that it is an effect, or an impression of the air upon the Plants.

M. Duhamel du Monceau [59] recognizes also the origin of the Rust from Fogs, but assures: *on appelle*, as he explains, *la Rouille une maladie, qui endommage les feuilles, et les tuyaux du Froment, en les couvrant d'une substance rousse, de la meme couleur de la Rouille du Fer. Cette substance tombe aisement des euilles. Les parties de la Plante qui sont attaquées de cette maladie, ne croissent presque plus. Si les Blés Sont reuillés quand ils sont encore jeunes, et avant que de monter en tuyaux, le mal est mediocre, parce qu'ils repussent de nouvelles feuilles, mais si la Rouille attaque les tuyaux encore jeunes, la Moisson en souffre beaucoup. On est assez communement persuadé, que cette maladie est produite par des Brouillards secs, et effectivament j'ai souvent remarqué, qu'apres de tels Brouillards, lor qu'il survenoit un Soleil ardent, les feuilles des Blés devenoient rouillées. Quand les Blés sont nouvellement attaqués de la Rouille, s'il survient une Pluie abondante qui lave les feuilles, le mal est presque destruit.* It is evident that this Great Man has not had the advantage of making opportune Observations on the Rust, because he would not have written that when it has fallen on the Leaves of the Wheat, it having formed the joint, the plant sends out new Leaves.

[58] In Scholio ad Georgii Hoyeri Obs. de Rore Melleo vitioso in Act. Acad. Nat. Cur. A. 9. & 10.

[59] Traité de la Colture des Terres, suivant les principes de Mons. Tull. ch. 17. p. 211.

So long as the Wheat has not made the body, as the Countrymen say, that is to say has not filled the spike, no weather can be propitious for the birth of the Rust, which has to have a certain determined degree of heat in the air; and moreover the Wheat plant on each of its stalks has a constant and determined number of Leaves; and not a single one more can be produced.

N. E. Tscharner Secretary of the *Società Economica* di Berna [60] thus explains the formation of the Rust. *To me it appears that this Malady has its source in Fogs, that appear at the end of Spring, which, most especially if the beginning of this Season has been humid, are very frequent in the country of Berne at the end of June. It manifests itself when the Spike has expanded, and arrived at a certain degree of consistency, and when the Leaves have attained their natural size. The little Wrinkles which many regard as the menace of the Rust, appear many times more quickly* (but this also is truly Rust, as will be made clear subsequently). *The Rust suddenly attacks the Leaves of the Plant, quickly passes to the Stem, and covers the Leaves and the Stem with spots similar to those that Rust produces on Iron. These spots observed with the aid of the Microscope, appear as little cracks, or fissures in the surface, or Epidermis of the stem and Leaves; the nutritive sap extravates through these cracks, becomes attached to the lips of the wounds, and dries there. Thus is this Disease formed. Whenever a thick Fog becomes attached to the Plants, the external parts dilate, and become thin, and if in this state of tension there occurs unexpectedly a violent exposure of the Sun, the Fibers or Filaments of the Skin of the stem and Leaves close up, and contract to an extent, proportionate to the violence of the heat which they have suffered externally. From this arises a constriction of the fibrous parts, and the sap is retarded or stopped in its circulation, producing an engorgement, that causes the little vessels to burst, whence arise the wounds or cracks, which appear externally on Plants attacked by the Rust. Such is the internal cause of this Malady; but there is another external cause. When that is to say the Cuticle of the stem softened and dilated by the Fog, is struck violently by the Sun, the result is an unequal shrinkage in the external parts, that causes the fissures, and the openings; which we are able to discern with the eye on the more considerable Plants, on the*

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[60] Memoires & Observations recuellies par la Societé Oeconomique de Berne, Année 1764. seconde Partie p. 30.

bark of Trees, and on the surface of strong ground. A stroke of ardent and violent Sun, can, after a Rain, produce the same effects, whenever it strikes in an area the Plants dilated by humidity. A third cause can produce this effect, that is to say when the Sun dries up in an area the great humidity of a Fog attached to a Plant. Then there can result a sudden spotting, which takes the color of the metallic parts contained in the Fog, and such a Rust eats insensibly into the still tender Cuticle of the Plant.

Some naturalists have been inclined to believe, that the Rust is an internal Malady of the Wheat, and of other Plants, that is to say a kind of Hemorrhage, or Flux of their nutritive saps, occurring by the rupture of the Canals which they contain. Thus Luca Scroekio in the above cited Commentary notes: *Licet ex ipsis etiam Vegetabilium poris, turgens in ipsis succus exsudare, et Rubiginem talem sistere possit.*[61]

M. de Tillet [62] thinks that the Rust, the Honeydew, the Floury Dew, and that greasy matter, that is conceived sometimes on the leaves of Grass Plants, Shrubs, and Trees, are always precipitated saps, that dry up little by little, become converted into an impalpable powder on certain Vegetables, and vary in color, according to the kinds of Plants, and the nature of the Trees where they are found.

A certain Mercarelli Factor of the Pistoiese, a few years ago having spread abroad a Writing upon the Rust, agreeably advised me of Sig. Doctor Bernardino Vitoni celebrated Doctor in Pistoia, who had at hand a copy of it. Mercarelli is of the opinion, *that the Rust comes from that humidity, with which the Chaff is impregnated in the month of June, more than is necessary, which humidity constrained to be carried outward in great quantity by the heat of the Sun, by means of the Transpiration, coagulates upon the Chaff, and forms the Rust. Upon the Chaff of the Rye* (Mercarelli goes on to say) *there never is Rust, and the reason is, because it comes into Fruit eight or ten days before the Wheat, that is to say when the humidity has departed, and the Plant has dried up and consolidated. In hilly country, in the greater part of the terrain little Rust is seen, because of the terrain being dry, the reverse of that of the valley. If the Rust comes from waters, and from Dews, every year there ought to be Rust, notwithstanding that year (and it would be at least seven or eight years) when in the month of June there had been excessive heat, and continuous*

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[61] See Gio. Christ. Magneni Exercit. de Manna c.1. § 1.

[62] See Ginanni delle Malattie de Grano in Erba Par. 3. cap. 1. § 8. n. 319. p. 295.

showers had come, nevertheless the Rust has not come. This objection alone, destroys completely the System of Mercarelli.

Leeuwenhoek cited by Ginanni [63] imagines that the Wind produces the Rust, with bursting of the fiber of the Chaff, from which occurs through the wound the precipitation of the sap which should nurture it, but so bizzare an opinion, contrary to good sense, is easily confuted by seeing the Rust appear without Winds, and by its not appearing on the broken Wheats, and being fostered by Hails, by furious Rains, and tempestuous Winds.

The Count Francesco Ginanni [64] expresses his system for the generation of the Rust, in these terms: *In the Cold of the night not proportionate to the heat of the day preceding, these malicious Constituents of the Air have been present, although sometimes not apparent to our senses. And from one such inclemency there should ordinarily be the Rust, as far as I can recognize and attribute diverse effects to it. It is not however that this same ratio of Cold and Heat, this disproportion of the diurnal and nocturnal air, by various means does not produce it, furnish the external cause, while the beginning of the Malady is internal. It produces the first kind, with suspension as if by suffocation in places either more open or more tender, or any little injuries of the plant, of the action of the humour which by insensible Transpiration the plant exhales, retaining it in the Internodes and indeed rendering these as if obstructed, by which then also all the regulated action of the liquid, that wanders in them is disturbed, and the greater the force, or less, the vaster, or more restricted the attack, according to the greater or lesser extension, or disposition of the parts subjected to the impression, which sometimes renders it so slight, that to the same spots the first color later returns too weak in this case being the impediment, or oppression of the air, which retains this material of the insensible Transpiration, hence the harm from it could be overcome, and then the same course takes again, that occurred earlier—often also it happens, that the action of the humour transpired by the Wheat Plant, by reason of the inclemency, becomes suppressed by the congealing of the same humour, which becomes condensed, and dries upon the Plant, or by the Mist which falls in such very small and almost insensible little particles, or by vapors and exhalations, which adhere even to their least particles; and*

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[63] Delle Malattie del Grano in Erbe Par. 3. cap. 1. § 13. n. 328.

[64] *Ibid.* § 2. p. 284.

indeed by this closing of the pores the delicate fibers of the surface can be torn, and that aridity is generated and that dryness of the leaves which they often cause to come upon the stems and upon the leaves. But by this same cause even the principal trunks of the nutritive sap can be ruptured, in such manner that the sap flows from the wound, and then come the darkest Rusts, and more damaging than the first, no less than the second kind, and the exuded humour disposes itself around the wound in the form of blackish Honey, as Hartsoeker [65] *avers, and there is discovered sometimes also the granular powder, with the Maggots within it. It perhaps is a mistake to say, that there is here any Rust of the second kind, which is a disease particularly of the Epidermis, originating through the corruption of a humour stagnating in the great humidities, on account of which the transpirable material not being permitted to be exhaled, extends over the leaf, and a ray of the Sun encountering it there hardens it, and causes the same leaf to crack, as it appears, and it splits, and in some places dissolves into powder, and thus it is as if a Leprosy were formed, and also a Moldiness.* He adds later:[66] *The Yellowness featured in powder in the internal parts of the involucres of the Wheat, and in the vesicles of the Epidermis of the leaf, cannot be suspected, of not being the same sap of the plant exuded by the little syphons, which send it upward to the Kernels, or to the leaf which it reaches and where it stagnates. A wound caused by Worms, by sour material, by fermentation, or by anything else, can rupture a side of these little syphons, and cause the disfiguring overflow.* Keeping always in mind the respect I owe this Gentleman who has such merit in Natural History, and who had always great kindness for me, I shall note that in Chapter I of Part I of his most Erudite Work, he distinguishes three kinds of Rusts on the Wheat, which in truth are not other than one and the same, that is to say that one which above I called the first Kind, considered in different ages and aspects. My description, which can be verified by anyone, easily uncovers the equivocation, and destroys completely the system of Hartsoecker, and of Count Ginanni, all the more because the dark color of the Rust of the Wheat does not depend on anything other than its being the dying, drying, and repeated burning of the Sun. The Wheat is not a Plant furnished with particular milky saps like the Tithymals, the Apocynums, certain Plants of the Chicoriaceae,

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[65] Extrait critique des Lettres de Mons. Leeuvenoeck.

[66] Par. 3. cap. 5. § 4. p. 348.

etc., which can exude from a wound or cracking of the Canals, and consolidate in the form of gummy material of dark color. Its saps are aqueous and scanty, hence from any crevice whatsoever, or cracking occurring in the stalk, and in the leaves, they do not ever exude, or pour out anything in a form discernible, even with the most acute Microscopes.

There is another respectable Band of modern Philosophers, who are of the opinion, that the Rust proceeds from an animate cause, that is to say that orange-colored substance which infects the Wheat in Grass, must be either wholly very minute Insects, or their Eggs, or their excrement, or sweat and tears of the Plant, from gnawings made there by Insects. Luca Scroeckio, in the above cited commentary, reports in abridgment the opinion of Ant. van Leeuwenhoek,[67] which supposes the Rust to be little Eggs of Insects, and adds that such sentiment had been held by Gio. Michel Fehrio,[68] Crist. Fed. Garmanno,[69] and Gio. Corrado Brunnero.[70]

The Celebrated Antonio Vallisnieri was of the opinion [71] that the Rust named in Lombardy, and in the Reggiano *Fumana,* and *Malume,* and which he believed to be the same thing as the *Uredo,* or *Carbuncularis Morbus* of the Ancients, is the sap of the kernels, and of the Spikes of corrupted Wheat, which by the gnawing of certain Worms is distilled from the lacerated vessels, and falls in drops, because on June 7 observing the Rust with a Microscope, he saw *a yellowish material, within which were writhing very little Maggots* of a vivid red color, from which on July 6 he saw certain Little Flies issue. Count Giuseppe Ginanni [72] describes such Insects, and refutes the opinion of Vallisnieri. I have had under my eyes a very great number of rusted stalks of the Wheat, brought to me fresh from diverse parts of our Territory, but I have not been able to find upon any of them even one Insect, such as is figured by Ginanni in Tav. 5, Fig. 12. I have nevertheless found on these stalks, and on those of many other Plants, even of very diverse kinds, a great number of those other Worms that the same Ginanni describes in the same Chapter at 28, p. 176, of a very vivid Carmine color, which have absolutely nothing to do with the Rust, whether

[67] See Continuatio Arcanorum Naturae Epist. 104. p. 149. See also one of his letters to me published on c. 347 of Vol. 2. Epistolarum Clarorum Belgarum ad Ant. Magliabechium.

[68] Tract. de Absinthio p. 65.

[69] Oologia Curiosa.

[70] Obs. 227 in Eph. Acad. Nat. Cur. Dec. 3. A.2.

[71] Della curiosa origine degli Sviluppi, e de' costumi ammirabili di multi Insetti Dial. 6. p. 73 in Vol. 1 of the whole Work, and Saggio d'Ist. Med. e Nat. in Vol. 3, p. 451.

[72] Delle Malattie del Grano in Erba Par. 2. cap. 9. § 24. p. 172.

or not by chance they feed on the globose fruits. I have moreover found them on Plants, on which there was not an atom of Rust, and I have noted that they do not greatly injure the leaves of these plants, as there were distinguishable no traces of gnawing, like those caused by many other Insects. The Brandley cited by the Count Ginanni [73] asserts he has observed, that Caterpillars ordinarily accompany in the month of March the sharp Wind of the East, and that these might be the cause of the Rust; but such an opinion cannot in any way be sustained, most especially because in years in which the Rust has fallen like snow, Winds of the Levant have not dominated, where Caterpillars were seen, and on the contrary in years in which Winds of the Levant, and Caterpillars have dominated, not an atom of Rust has been seen. The same Count Francesco Ginanni [74] describes the Rust observed by him on the Wheat, on the day May 29, 1753, in these terms: *Unexpectedly there was also that of the second kind, which I saw on the morning of the day May 29 spread upon the stems, the leaves and the Beards of the Wheat. A viscous humour, or one might say a yellowish pus appeared there first, and afterwards a granular powder within this humour, similar to the frass of the Woodworm, deep yellow-red in color, which extended from one side of the leaves to the other, and insinuated itself into the stems, corroding the fibers. I did not always however, see the viscous humidity, sometimes black, and sometimes colored a vivid yellow, change to the granular powder.* From such terms it is indubitable, that Count Ginanni describes the Rust which I called the first kind, but which is considered the second by various other persons. Now within this Rust he observed certain very tiny Caterpillars, hidden between one membrane and another of the stalks of the Wheat, and among the little globules of the powder of this Rust, which he describes minutely on p. 63. He adds then on p. 67 that such Caterpillars gnaw the stems, and the leaves of the Wheat, and on p. 67 says: *The corrosions by the Insect described by me, are in the external rind of the stem, of the leaf, and of the beard, out of which the Worm has excreted certain material, similar to that which the Woodworm* [75] *produces. These corrosions do not extend always from top to bottom, but are often times transversal, and sometimes are compelled to incline to the flat.* Count Ginanni represents, that the cracking of the Cuticle of the Wheat, which I described on p. 292, and noted to be occasioned by the increasing mass of the Little Plants of the

[73] Par. 3. cap. 1. § 14. p. 305.

[74] Par. 2. cap. 5. § 4. p. 61.

[75] See also Par. 3. cap. 1. § 8. p. 295. and cap. 5. § 4. p. 348.

Rust, is the gnawings of Worms, and believes that where such cracks appear there is no Rust, and as a consequence Worms should not be found there. Therefore he adds: *Certain it is that in the Rust of the first kind, in whose gnawed dark spots, that blast, scorch, and make barren the Little Plants of the Wheat, and that attack every other Plant* (which, according to my Observations, is the residue of tufts of aged Rust, over ripe, and dried up by the Sun) *although more and more times I sharpened the eyebrow, I have never been able to see any granular powder* (which however is there, but attenuated, as I noted on p. 291) *nor Worms, nor Verminous corrosion. This is found only in the thick and viscous humidity,* that is to say when the Rust is fresh and vigorous, and with its increase in mass causing the Cuticle of the Wheat to crack, and pour out its little globules. The reasons which Count Ginanni [76] adduces to demonstrate, that the little gnawing Worms described by Vallisnieri, do not produce the Rust, show with equal certainty that not even the very minute green Caterpillars, nor the tiny chaff, which the same Ginanni observed, produce it. It may be added that N. E. Tscharner, Secretary of the Economic Society of Berne,[77] is of the opinion, that the very tiny Insects are a consequence, not the cause of the Rust.

If I do not flatter myself too much, I believe I have made it sufficiently clear, that the Rust is not other, than a Microscopic Parasitic Plantlet, which is not borne except between skin and skin, so to speak, of the Wheat, and of other Plants; hence the Theories of the sanest Philosophy, which bring so much honor to our Galilean School, now reduced to axioms, persuade us easily, that it ought to be born of its own proper seed. The smallness then in its entirety of a plantlet of the Rust, even of the greatest rankness, forces the belief, that these seeds are of a scarcely credible smallness, such that they could not be seen with even the most acute Microscopes. I expressly noted, that the dactyliform Little Bodies, or Fruits of the Rust of the first kind, when they are old and dry, exhibit a dark spot on one of their sides, and conjectured that this depended upon there being an accumulation of little seeds dried up there. However this may be, it certainly must be supposed, that the Rust has seeds of an extreme minuteness, capable of being scattered about by the air, without our eyes being able to discern them, and capable likewise of flying here and there, even to a distance, on the wings of the Winds. Chambers [78] notes that the disturbance of the Rust, by

[76] Par. 2. cap. 11. § 8. p. 245.

[77] Memoires & Observations recuellies par la Societé Oeconomique de Berne, An. 1764, seconde Partie p. 32. & 37.

[78] See Ginanni Par. 3. cap. 1. n. 327. p. 302.

The English called Bright, happens when the strong Winds of the East blow, which are very frequent in England in the months of March and April: in Tuscany, on the other hand, the Rust can fall like large snow flakes after Winds of the West have dominated, by reason of the different situation of the Ocean. *Il Flotte,* says Pietro van Musschenbroek,[79] *dans l'Air des semences de très petites Plantes, et de petits Oeufs d'un nombre infini d'Insects, qui tombent de l'Air a terre en mème temps que la Pluie. De la vient qu'on voit croitre dans cette eau non seulement des Plantes vertes, mais qu'on y découvre aussi un nombre prodigieux de petits Animaux, et de Vers, qui la font comme fermenter, et lui communiquent une mauvaise odeur par leur corruption.* This proves that the Little Seeds of Microscopic Plants, even though very small, are able to resist for a great space of time the injuries of the Air, and keep themselves fecund, and capable of germinating as soon as the circumstances of the Environment are favorable to them, which is verified also in the Little Seeds of the different kinds of Rust. The better to be persuaded of this so long enduring vivacity of the Little Seeds of such very minute Plants, it is enough to be reminded, that also the Seeds of Herbaceous Plants of rather notable size, maintain themselves uncorrupted and fecund in the same territory, whenever there does not come a season propitious for germination, and often they await it for very many years.[80] It is certain that there are many years in which the Cockleweed is not seen, nor wild Oats among the Grain; but there comes then a year, when these ominous plants arise in great quantity, and suffocate the Grain. It is certain likewise that the Seeds of the Chokeweed scattered over a territory, if in this territory there is not seeded for many years any Pod-producing Plant, do not germinate; but if by misfortune some sort of seeding occurs, behold how suddenly the Chokeweeds arise there also, and shooting their roots into those of the Pod-producing Plants, they ruin them, and come up rankly, producing about 3,000 Little Seeds each, which fall to the ground, to remain there as in deposit, and inert, until such time as a new seeding of Pod-producing Plants is made.

By analogy with these known facts, we are able easily to understand, that the Little Seeds of the Rust are capable of maintaining themselves sound, uncorrupted, and fecund for Years, that is to say until there intervenes an occasion favorable for them to germinate.

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[79] Essai de Physique T. 2. c. 39. § 1549.

[80] See Io. Raii Hist. Plant. L. 1. c. 13. p. 25. & Catal. Plantarum Angliae p. 295 & 100. Iul. Caes. Scaligeri Adnot. ad Libros duos de Plantis Aristoteli ad scriptos p. 97. Theophrasti Hist. Plantarum Lib. 8. c. 11. Io. Targioni Tozzetti Appendix ad Petri Ant. Michelii Catalogum Plantarum Horti Caesarei Florentini p. 127.

This, according to the Observations of the Ancients, recorded punctiliously by Theophrastus, and verified by the Moderns, is such a constitution of the Air in the Spring, that when the Winds of the Sea that have dominated earlier become calm, and the Sun stands above our Hemisphere, and particularly in the Full Moons, that is to say between the first and last quarters of the Moon, there is exhaled to a serene sky from the ground, and from the Vegetables which invest it, a large amount of water Vapor, mixed with large portions of salty and sulfurous particles. This great mass of Vapors floating through the Atmosphere, at the end of the day, when coolness is sensible, condenses, reunites, disturbs the serenity of the lower Air, forming a Darkness or humid Fog, cold, and somewhat foetid, and finally reuniting still more, and forming somewhat larger globules, precipitates downward in the form of very fine rain, and is deposited upon the Vegetables in the shape of very little shots of water. After there has occurred this falling, and deposition of the pernicious Dew, which by the Countrymen is easily distinguished from the beneficial Dews, and is called *noxious Dew,* the air is purged, and again becomes diaphanous, and the Sun with its scourging rays quickly dries up this Dew, and dissipates it. But the mischief has already been done to the Wheat, even though not an atom of the Rust may have been seen, *si culmos Titan incalfacit udos,* as Ovid elegantly says, that is to say as soon as the Sun has dried up the injurious Dew, the Rust already is discovered growing between skin and skin so to speak of the Wheat, and of other Plants, and in a few hours it grows, and swells to the point of causing the Cuticle of these plants to crack; within which it was born and buried, and can scatter abroad its already mature fruits. So rapid Vegetation is not a paradox, nor without example: for everyday before our eyes various kinds of Molds, and of Fungi, are born in a few hours, grow, and mature seed, and with equal velocity many Microscopic animals grow, and propagate. It has moreover been constantly observed by the Ancients, and the Moderns, that if after the falling of the noxious Dew, a Wind arises that destroys and dissipates it, or a Rain supervenes, the Seeds of the Rust do not grow, and do not have means of advancing towards their vegetation. Thus therefore with difficulty are combined all the circumstances favorable to the scattering of the seeds of the Rust, and to their germination, and felicitous vegetation, so that although their little seeds are always scattered in the air and on the ground, by Divine Mercy it rarely happens that they are able to do great damage to the Wheat, and to the Oats, and commonly the Rust does not occur except in some years, *in Roscido tractu, Convallibusque, ac perflatum non habentibus,* as Pliny expresses it.

Count Ginanni [81] thus describes the Dew, after which the Rust becomes manifest. *Towards the end of the day June 11 the little plants of the Wheat were made wet by a subtile humour, and vaporous, which damaged some without having caused their death, but a little later changed their color, and completely tinted them yellow. Came the Sun, drying them, and those that remained were sunburned. I have seen at other times this humidity, or Dew, or subtile Mist not entirely dried, and that began to stain the Little Plant. To assure myself that this, and not another humidity acted to produce this effect, I dried many leaves diligently, and afterwards sprinkled some with common water, others with rain water, and all were safe from this Rust, but those contiguous wetted by the nocturnal humidity, remained infected.*

As therefore the Rust has some connection with the Mist, or Dew, it will be advantageous to say something regarding the Dew, not for the purpose of making a long digression here upon such material, but to satisfy the curiosity of some Readers, by indicating to them the Books which treat instructively and make the question clear. Passing over therefore Aristotle *Problem.* sect. 25 *Problem.* 21, P. Niccolo Cabeo *in Aristot. Meteorolog. L. 1, Tex. 50, Quaest. 1, p. 289,* Gio. Ridolfo Camerario *Sylloges Memorabilium Medicinae, et Mirabilium Naturae Arcanorum Cent. 9, N. 49, 50, 51 and 52,* Liberto Fromond *Meteorologic. L. 5,* c. *4,* and our Giovanni Nardi, who published a Treatise *de Rore,* I shall note that better than all others the Celebrated Philosopher Pietro van Musschenbroek in his *Essai de Physique Tom. 2, cap. 39, des Meteores Aqueuses al § 1530, et seq.* has made clearer the true nature, the differences, and the effects of the Dew. Modern Philosophers have doubted, whether the humidity of the Dew rises up from the ground to the Sky, or falls from the Sky to the ground. See *Musschenbr. § 1535 F. Fortunati de Felice Adnot, in 1° Arbuthnot specim. Edsectuum Aeris et c. p. 14, n. 20 et seq.; Ginanni delle Mallatie del Grano in Erba p. 74 and 75.* Concerning the times, and the hours in which the Dew can fall, see Zaccaria Efraim Bernero *de Efficacia et usu Aeris Mechanico in Corpore Humano 118 et 119,* and Musschenbroek § *1538;* and concerning the quantity of Dew that falls in a night, see the same Musschenbroeck § *1539,* and Hales *Statique des Vegetaux ch. 4.* The Nature and the Components of the Dew, have been made clear by means of chemical analysis, by Francesco Veratti *Notomia dell'Acqua p. 32, 36,* and *38,* by Giuseppe Lanzoni *Operum T. 3,*

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[81] Par. 2. c. 5. § 131. p. 72.

p. 618, by Bernardino Ramazzini *de Constitutione Anni 1690,* by Ermanno Boerhaave *Elem. Chem. T.1, Pars altera de Artis theoria p. 234,* by Count Franc. Ginanni *delle Malattie del Grano in Erba Par. 2, c. 5, § 5,* and by Musschenbroeck § *1540.*

Most of the time the humidity of the Dew is innocent, and useful to the Plant: there is damage however at certain seasons, when this humidity is full of saline, and sulfurous, substances, and becomes injurious to Plants and Animals. The theory of more abundant, and more active mixtures of such substances with the water vapor, can be seen quickly in the above cited Bernero § *125* and *129*, and Count Ginanni *Par. 3, c. 1, § 6, et seq.* P. F. Fortunato de'Felici in *Arbuthnot Spec. n. 23 et seq.* causes it to be seen, that on hot days, from Fields seeded to Wheat and Oats, there rises upward an immense quantity of exhalations, and that therefore the Dews grow more saline, and acquire a somewhat Caustic nature, and Musschenbroek § *1490,* makes clear the incredible mixtures of very different substances, that swim through our low Atmosphere, waters, salts, sulphurs, soils, animals, and vegetables, among which the very minute seeds of many Plants, as Mosses, Lichens, Molds, etc. deserve mention. Concerning these Caustic Dews, one may see Gio. Ridolfo Camerario *Syllog. Memorabil. Medic. Cent. 9, n. 49,* Musschenbroek § *1534,* Sig. Abbot Lazzero Spallanzani *Saggio di Osservazioni Microscopiche Cap. 10, p. 79,* Plutarch *Quaestionum Natural. p. 419,* Gio. Matteo Fabro *Addenda ad Decur. 2, A.8, Ephemer. Acad. Nat. Cur. A. 1690, p. 465,* Paolo Boccone *Osservazioni Naturali p. 183* and Count Francesco Ginanni *delle Malattie del Grano in Erba Par. 2, cap. 5, § 15, et seq.,* and also I have noted something in my *Ragionamento sopra le Cause, e sopra i Rimedi dell'Insalubrita d'Aria della Valdinievole p. 439* and *493.*

There is Observation by Theophrastus [82] that the Rust *Pleniluniis magis creatur, quoniam Lunae quoque caliditas putredinem auget, et omnino Aer humidior—ratio in calore est, quo etiam noctu Luna putrefacere potest;* at which place notes Giulio Cesare Scaligero: *Solstitiis noctes aestuosae sub Plenilunio.* Also Berizio [83] says: *Nosse autem operae precium est, quod Pleniluniis maxime omnia a Rubigine impetuntur, praecipue vero Frumentum, propterea quod tunc Luna calidissima sit et humida, noctuque fructus putrefaciat.* Pliny affirms also this [84] that the Rust *nisi noctibus, et ante Solis ardorem deprae-benditur, totumque Lunari ratione constat; quoniam talis*

[82] De Causis Plant. L. 4. c. 15 & L. 3. c. 27.

[83] In Geoponicis Graecis L. 5. c. 31.

[84] Nat. Hist. L. 18. c. 28.

iniuria non fit nisi Interlunio, Plenave Luna, hoc est praevalente, utroque enim habitu plena est—Interlunio Aestate calidissima est, Hyeme gelida; e contrario in Plenilunio Aestate gelidas facit noctes, Hyeme tepidas. Moreover Pliny is of the opinion, that not the supposed heat of the Moon, but the cool moistness of the air, facilitates the vegetation of the Rust, and Count Francesco Ginanni [85] avers: *The Rusts find most favorable nights, that can be regarded as cold, in proportion to the warmth of the day.* Colonne [86] expresses himself: *nous croyons avec les Jardiniers, et autres bonnes Gens experimentés, que l'Air est plus humide quand la Lune est plus lumineuse, et ces Personnes disent, que toutes choses egales, les Plantes croissent mieux dans ce tems, que dans un autre.* To me it is significant that in 1747 the Full Moon was on the day June 22, and the night of the 23rd there was a Fog, or very great Dew, after which on the day of Saint Giovanni a copious Rust was discovered. In this year 1766, the moon was at Full precisely on May 24; the day June 2 marked the last quarter; on the 8th the Moon was new, and the 15th was the quarter, and the day July 7 the Moon was new: but on the day June 8, as well as on the day July 7 much Rust was discovered; thus is rendered fallacious the rule of the Ancients, that the Rust manifests itself in the Full Moons. Lodovico Vives [87] very justly says, that *ad Auroram solet id vitium segetibus accidere, silente Coelo, serenisque noctibus.*

In the Region of Rome, which is much more southern than ours, and where the Ripening comes more quickly, it appears that the Rust usually manifests itself much earlier than with us, that is to say at the end of April, although the *Feste Rubigale* was celebrated in ancient Rome on April 25. In Tuscany, and in the Provinces of Italy which are a little more Northern, the Rust not having been noticed being born before the last days of May, it is well to say of its seeds, that they have not found earlier than those days, such a favorable combination of a certain degree of Heat, and of a determined quantity of moisture in the low Atmosphere, as would enable them to develop easily, and vegetate. It was seen, that the Seedings having been made much too late, that is to say after the 13th day of November 1544, the months of January and February, 1545, were wet, so that the Wheat in the Fields was in color light green, with few stalks per tuft, with few roots, and of little height, but had mixed with it much Oats, and many Weeds. In April and May there were good times, but it rained often, and the Wheat became

[85] Delle Malattie del Grano in Erba Par. 2. c. 5. § 8.

[86] Hist. Nat. de l'Univers T. 3. p. 138.

[87] Commet. in S. August. de Civit. Dei L. 4. c. 41.

rank; but at the last of May there came certain Fogs, and the Temperatures began to be high, so that the Grains commenced to grow rusty, and developed grain badly, hence the Harvest proved wretched, especially in the Plains. According to the Observations of the Celebrated Bernardino Ramazzini [88] in 1689 in Modena there were great Rains about at the Spring Equinox, which being repeated time after time, rendered all the Spring humid and cool, and the Summer likewise was rainy. Toward the Summer Solstice the Rust began to appear, and successively multiplying, tormented the Wheat and the Legumes, and made the Harvest wretched. The Winter of the succeeding year 1690 was mild, but humid, and rainy. March then was dry, and very beautiful up to the day of the Equinox, on which it appeared as if the Cataracts of the Sky had burst, and there lasted for an entire day an excessive Rain, that flooded the Country; thence for all the rest of the Spring, and into the Summer, the rainy constitution continued, in a manner such that in Modena no day passed on which it did not rain more or less, and neither Spring nor Summer were distinct. The Rust in this year began to appear in the first days of June, on the leaves of the Mulberry Trees, then multiplying horribly, and it did immense damage to the Grains and to the Beans, more than to all other Plants, but destroyed also the Potherbs of the Gardens, the Summer Fruits, and the Grapes. In Tuscany after the horrible cold of January, 1709, there were many Rains in February, which were repeated also in the months of March, April, and May. The Grains showed well, but the days June 28 and 29 carried away the Wheat and Grape. In 1747 I recorded, that the Rust appeared on the day of Saint Giovanni in our Region. Indeed in the Meteorological Observations of Count Francesco Ginanni [89] it appears noted, that in the Plain of Ravenna the Rust began to appear in the year 1750 on the days April 4 and 14. In 1751, at the end of April, in 1753, after the day May 12; and 1755, at the end of February; but I fear that this Author considered as Rust, also certain yellowings of the leaves of the Wheat, that happen for other reasons. At least seemingly it ought to be deduced from his Observations, that in truth Rust appeared in 1750 at the middle of June; in 1751 and 1753, at the beginning of June; and in 1754, on the day June 11.

Nec Segetum situs, noted Theophrastus,[90] *naturaque parum refert Tractus enim excelsi, perflatique, Rubiginem nullam, aut minimam sentiunt, concavi, et flatibus* (that is to the Winds from the Sea) *expositi, contra frequentissimam habent.*

[88] De Constitutione Anni 1690. p. 7.

[89] Delle Malattie del Grano in Erba Par. 2. cap. 1. *et seq.*

[90] Hist. Plantar. L. 8. c. 10.

This is what happens most times: but Count Ginanni [91] observed, that the Rust in 1751 spread over the more elevated parts of the Territory of Ravenna, not in the lower; and he noted [92] that a clump of Wheat growing under a Shed, rusted in the middle of May 1756.

The Little Seeds of the Rust being of a smallness so astonishing, they can easily fly through the air, without our eyes being able to discern them, and they can readily be transported on the wings of the Winds here and there, even to distant places, and come to be deposited on the surfaces of the Plants, greatly revived by humidity from the air, manifesting in their skin a certain viscosity, such as happens in the seeds of some Larger Plants. The Little Seeds of the Molds, of the Lichens, of the Mosses, of the Lichens, of various Capillary Plants, etc. float thus all day invisible through the air, and thus float the eggs of innumerable races of Microscopic Insects.[93]

Count Ginanni says:[94] *Some Grains were separated from a Spike; these on a side towards the Blossom have from skin to skin an evil very black material, that causes their skin to be somewhat raised, but of the paste nothing is lost. The black depth of this corruption, was very different from the color of the Soot* (which we call Carbonchio) *and from the material of the Wheat Smut* (that is to say of the *Volpe*) *as much also different was the Dregs of the dissolution, that occurs there a little later.* Then he [95] notes: *Not much different from the Rust seems a Mold, that at some rare times is born on the lower leaves of the Wheat, and now and then on the lower part of the Spike of the same, after a Rain of many days. I saw this in some heavily planted Fields on the day May 28, 1752, after a Rain of almost six continuous days, and this moreover I found elsewhere on the 10th day of June, 1755, after it had rained for a good ten days, with little interval of the time cloudy. There was also on the Hops one such Mold in England, on which it was considered more frequent by the most estimable Hales,*[96] *than on the Wheat in Grass.* If such kinds of Molds as these are Plants, as it appears ought to be believed, and if they propagate thus nested on the Wheat, and on the Hops, it is yet necessary to be persuaded that their seeds are capable of floating through the air, and by the agitation by the

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[91] Par. 2. cap. 5. § 6.

[92] Pag. 81. § 25.

[93] See Boerhaave Chemiae T. 1. p. 243. 244. Io. Arbuthnot Specimen effectuum Aeris in Corpore Humano cum adn. F. Fortun. de Felici p. 22.

[94] Par. 2. c. 6. § 15. p. 90.

[95] Par. 2. c. 5. § 21. p. 79.

[96] Statique des Veget. cap. 1. Exp. 9.

Winds, being carried here and there, and being deposited on the Plants, where helped by the coolness, and by the humidity, they are able to develop and vegetate. If this then occurs readily with the seeds of the Mold, why then can it not happen with those of the Rust, which are about equal in size and shape? And why if the Mold [97] is a Plant, ought not the Rust, be also, so analogous in structure, and in fructification? In other years, I have seen the kernels of the Wheat stained, or pock-marked wirh black in only the rind; and in various rainy years, and most especially in 1765, the Chaff has been all infected with dark spots, resulting from the very small tufts of Lichen, or Mold, growing thereon.

N. E. Tscharner [98] thus epilogizes the Phenomena of the Rust. *This Malady is manifested principally in the low Fields, situated in the Valleys, along the waters and the Streams, or places near to marshes and springs of waters, from which arise the late Fogs; the high places, and the dry Fields rarely are subjected to it. This does not necessarily deny, that the Rougeole, which has much relation to the Rust, manifests itself sometimes in the dry Fields, but this can have as cause the impression of caustic particles mixed with Fog. Thus it is that the Swiss Countrymen believe, that it is produced by the copious Dews of the Summer. When the droplets attached to the Plants, have all been dried up in a space by the ardent Sun, they form a reddish spot, and a Rust extremely corrosive, and penetrating.* 2. *Experience shows that in the years which have dry Springs, which rarely occur in Switzerland, the Wheat does not suffer from this disease; but in years of wet Springs, and late, it is a rare thing when the Rust does not attack the Wheat.* 3. *The Rust does not ever become manifest before the Wheat has unfolded its ears; and attacks the weak Plants, more than the strong, and those in wet Fields more than those in dry Fields.* 4. *This accident happens to many Plants at the same time, and often the Rust occupies the whole extent of an entire Countryside, which becomes yellow in a few days.* 5. *A wet soil produces Plants too watery and weak, with saps prone to ferment, with vessels easily stopped up, with thin integuments, and with the fibers too tender, which consequently the time, and the Season, are able to influence to advantage. A Field situated in the Marsh of Belp, on which by order there had been*

[97] See Michelli Nova Plantarum Gen. Magazzino Universale pubblicato in Venezia, Primo numero p. 303.

[98] Memoires & Observations recuellies par la Societé Oeconom. de Berne A. 1764. 2. Par. p. 33.

scattered burned soil, and ashes, resisted the rust for a longer time, than the other contiguous Fields, which had been manured, and although it became infected with the Rust at the same time as the others, it remained green considerably longer, in the midst of the yellowed Fields which surrounded it, and yielded a better crop. It is not possible to adduce a reason for such a difference, other than a more substantial sap in the more vigorous Plants, such being due to the governing heat, absorption, and drying out, from which this soil had benefited. 6. *The Season can also contribute to accelerating the evil: the more there is of heat and the drier the time, the more likewise the evil spreads, and augments quickly.* 7. *The Locality, or indeed the position of the Field, finally, contributes not a little. Fields exposed at Midday, and to the East, and surrounded by Woods, and by Cliffs, which reunite the Rays of the Sun causing a greater heat, are much more subject to the Rust.*

One should inquire for what reason the tufts of the Rusts of different kinds, or varieties, nestle, or sprout in the lower faces of the leaves of diverse Plants, rather than in the upper. I cannot give any other answer, than to agree with the Celebrated M. Carlo Bonnet,[99] that in the majority of Plants, the upper surfaces of the leaves serve for the daily Transpiration of these Plants, and the lower for the Inspiration, that is to say to absorb the humidity scattered through the air, whether it be of Rain, of Dew, or of Vapors exhaled from the soil, and by Vegetables. At the same time then, that the leaves by the little inhaling mouths of their vessels, or absorbing, scattered through the lower face of the leaves, suck up the humidity floating in the air, it is credible that they suck up also the Little Seeds of the Rust, which are indeed of an imperceptible smallness, and of a specific gravity about equal to the smallest molecules of the vapors, and of the Dews. Concerning this proposal it is convenient to note, that the Celebrated Pietro van Musschenbroek [100] has put forward an Observation made already by Bodino, that is to say that there occurs a certain such Dew of globular droplets, different from the moisture of the other sorts of Dews, and of the Fogs, which is found attached to the Leaves, and of other parts of Plants. With decisive Experience, and with strong reasons he proves, that this particular moisture curdling in round droplets, is properly speaking, a Sweat of the same Plants, that is to say their Transpiration, which not having been dissipated by the heat of the

[99] Recherches sur l'usage des Feuilles 1. Mem. p. 3. & 53.

[100] Essai de Physique Tom. 2. c. 9. des Meteores Aqueuses § 1533 *et seq*

Sun, nor by the Winds, is coagulated in the form of rain drizzle by the coolness of the night, and at daybreak. Of this nature perhaps are the droplets of very limpid water, which on the day October 16, 1742, I found attached to the summits of all the little hairs of Plants of the Cisalpine Tithymale *Caracia,* as I noted on p. 278 of Vol. 1 of my Journeys. Undoubtedly then I observed this kind of sweat, in great quantity, upon very many Plants in the course of the Summer of 1766, early in the morning, where the Sun had not shown very much, mostly upon the tips of the little hairs, which seem to be excretory canals for this sweat. Could it be conjectured, that in certain entire nights of the Spring especially, the Transpiration of the Little Plants of the Wheat, condensed by the coolness in form of rain drizzles on the mouths of the canals, through which alone it ordinarily is exhaled, happens as a consequence to imprison, and bind up within its droplets the very minute seeds of the Rust, scattered and floating in the air, and these make a quick development, and vegetate the following morning, when the rays of the Sun work upon them? This simple conjecture merits some examination, to verify whether the Dew, after which the Rust manifests itself, is one of the common ones, or is a Sweat of the Plants.

With the Hypothesis of saline caustic Dews, or else of Gangrene from the burning occasioned by the convergent rays of the Sun, passing through the tiny globules of water, or of Dew, it is easily understood how the Plants become offended by the Rust; but assuming that this Rust is a Parasitic Little Plant, it is necessary to explain the manner in which it produces injury in the Plants, within which it is born and grows.

Repairing then to the Cereal Plants, which are those with which Rust makes the greatest slaughter, it is necessary to recall what was said, that is that their Arterial Canals, which carry the nutritive humour to the Ear, are all situated in the outer surface of the culms or joints of the stalk, and of the leaves, immediately beneath the very delicate Cuticle. Whenever then the Little Seeds of the Rust come to rest upon the same stalk, finding some open mouths of the exhaling vessels, there they enchase their minute radical fibers, and there they infiltrate in such a manner, that they graft into the tender and delicate arteries peculiar to the Plant, which from this moment onwards become Arteries of the Rust, and cease to be in respect to that portion of the stalk, that from the point precisely where the radical fibers of this Rust are enchased, propagates finally to the summit of the Ear. Such inosculation of the radical fibers of the Rust with the arterial canals of the Cereal Plants, happens with the same facility, as everyday grafts of whatever sort we see perfectly and stablely inosculated, and so to speak, identifying the arterial

Canals of the Small Branch, or of the Bud of the Graft, with those of the tree on which the Graft is made, and it appears, by way of example, that the roots of the Wild Orange Tree, become fatigued from sucking from the ground the food to be carried to the Lime Tree, and those of the ordinary Jessamine, to be carried to the *Mugherino*. With the same Mechanism the Orobanche, or ordinary Chokeweed with white flowers, appropriates the roots of the Leguminous Plants, called by the Countrymen *Baccelline;* the Chokeweed with bronze flowers appropriates those of the Common Broom, or Ginestra Juncea, or the *Scoppiereccia,* and of the Goatsbeard, or Ginestra quadrata; and the Chokeweed with yellow flowers appropriates those of the Ivy.[101] Thus moreover the Cistus, enchases itself on the roots of various kinds of Winterberry on the warm sea shores of Linguadoca, of Spain, and of Portugal;[102] the Dentaria, or *Anblato,* enchases itself on the roots of old Trees, and specially on the Hazel nuts; the Cistus enchases itself on the roots of the Firs, and the Pines;[103] finally the *Cinomoria,* or Fungus of Malta, enchases itself on the roots of the Mastic Tree, of the Myrtle, of the Alimos or Portulacca Marina, and of the Kali, or arborescent *Vermicolare Marina*.[104] As such shrubby Plants have many roots, and hard, if any one of them should be usurped by one of the above noted Parasitic Plants, there would be no great injury, although in Maremma, and at Valombrosa, I have seen quite large and tall Plants of the Ginestras dried up, from the Chokeweed borne on their roots. The poor *Baccelline* Plants, herbaceous, annuals, and needful of much sap, if their master roots become invested by those of the Chokeweed, quickly react and the nutriment fails them, and they perish and die. The Bird-lime, or *Pania,* also enchases its base and radical expansion in the hard branches of the Chestnut, Green Oak, Pear, and Apple, with a mechanism observed by Malpighi,[105] and inosculates the arterial canals of these branches in such a way, that it draws up from them all the nourishment: *Tanta est vis huiusmodi insitae, ut ita dicam, Plantae, ut subiecti rami exhausta alimonia, vitiataque structura, vel monstruosi reddantur, vel temporis diuturnitate exsiccentur.* More precisely Malpighi explains, in discoursing on the nutrition of the Parasitic Plants:[106] *Plantulas igitur,* he says, *e diversis vegetantibus assurgentes lustravimus. Hae quasi insitione*

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[101] See Michelli dell'Orobanche, Raii Hist. T. 2. p. 1227.

[102] Clus. Hist. p. 68. and 79. Raii Hist. T.2. p. 1228.

[103] De Plantis quae in aliis vegetant. p. 140.

[104] Morison Hist. Oxon. Par. 3. p. 503.

[105] De Plantis quae in aliis vegetant. p. 140.

[106] *Ibid.* p. 144.

unitae, a contiguis vasculis et utriculis communem materiam exhauriunt, et in propriam vertunt alimoniam.

This supposes, if the tufts of the Rust are few, and are rare on the stems of the Wheat, and of the Oats, little will be the injury which they will cause; as also if the Rust should be born late, and when the seeds of the Wheat and the Oats already are in wax, well nourished, and almost mature, and if finally it is born on the leaves only. But if, as happened in 1766, the Rust should be born very early, and found the Plants of the Wheat, and of the Oats, tender and sappy, and then time after time it should be born anew, and always in greater quantity, immense is the mischief which it causes, because it makes, so to speak, a pasture of the Wheat, and invests the Arteries to such an extent, that hardly any of them are left, capable of carrying the necessary nutriment to the Ear. The Chaff becomes all spotted, and spoiled by the Rust, but this would be a small evil, because it is not found harmful to the Beasts which eat it; as to the remainder it does not suffer sensible alteration, and does not wither, nor dry up early, like the Plants ravaged by Chokeweeds, etc. The fatal destruction occurs only in the kernels of the Frumentaceous Plants, which not withstanding that they were in the beginning healthy, fecund, well formed, and organized, being deprived of the nutriment necessary to them, sucked away by the Little Plants of the Rust, even as by a Leech, become no more good than nothing, and remain shriveled, deprived of sap, and like little bags of Bran with little or no meal in them.

To better understand how the Rust always can make an alteration so much more appreciable in the seeds, than in the stems of Frumentaceous Plants, it is necessary to be well informed upon the internal structure of the Seeds. I therefore will be so bold as to explain what I have succeeded in ascertaining on this subject, by many diligent Observations, which can be easily verified by whoever wishes to do so. There was no thought of this early on the morning of June 18, when at the House of Sig. Doctor Carlo Alfonsa Guadagni, examining the *Volpe* of the Wheat, I desired to take all possible care, to understand in what manner, the little seed of the *Volpe* could penetrate, within the tender kernel of the Wheat, and how it could amass so prodigious a quantity of the minute little globes described below, all equal in shape and mass, which occupy the entire cavity, and destory the usual Farinaceous substance of the Kernel, and do not permit even an atom of it to be formed. I saw at that time, that the other Kernels of the *Gentile* Wheat, on the same Ears on which I made the observations, contemporaneous, and healthy, were full of a white, soft, glutinous, and milky substance, which placed under the Microscope, appeared an amassment of

innumerable little Bodies globose and smooth (see Fig. 32), which separated from one another with the assistance of a little pure water, to observe them more perfectly, and circumscribed they retained constantly their globose shape, but a little crushed, in the manner of Vesicles whitely transparent, but yet smaller than the little globules of the Rust of the eighth kind, and of the *Volpe,* and not all of precisely the same size, but with some little diversity. Their transparency therefore appeared to distinguish them, when they were strongly illuminated from below by the reflecting Mirror, but without being thus illuminated, these Vesicles appeared as little white globes. In the prosecution then of the Observations, I was certain that the Conglobate Leaf, as Malpighi calls it, or Farinaceous Pulp, or Uterine Placenta of the Kernel of the Wheat, whether in that precise degree of age, that by the Countrymen is specified by the name *Wheat in Milk,* or also in a more advanced age, and approaching perfect maturity, which is called *Wheat in Wax,* and also when dry, is the only part of the plant of the Wheat, that presents the described Vesicles, as indicated also on page 237; that is to say the Wheat in Milk makes them appear immediately after it is crushed on the isinglass of the Microscope; the Wheat in Wax upon being pressed out, and disintegrated with water; and some three years old of a kind of Hardness, have become for me a very little larger, and tougher, when held to macerate in water for 24 hours. Such vesicles subjected to the same enlargement by the Microscopes of Sig. Doctor Guadagni, appeared not entirely uniform in size; but they were smaller by a third, and even by a half than the others. In the dashing about that they do among themselves, when placed on glass within water that disperses them, they were never seen to unite, or compenetrate, that is to say two or three did not make one, as commonly can happen with little bubbles, or droplets of oily or soapy substances, while according to the observations of the Chemists, Oils dissolved and agitated in water, become White.[107] They all appear equally transparent, except that they are lightly shaded with white, as in certain Oriental Jewels, and of such perfect water, that the hint of color is hardly distinguishable. This transparency of the Vesicles of the Milk of the Wheat, was maintained also when they were piled up, that is to say superposed doubly and triply, and with the most perfect Spirit of Wine poured on them they do not become disengaged, nor unite together, nor compenetrate, but only remained piled up. I tried another time after the water was exhaled where they were swimming, and they were resting only on

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[107] *Color lacteus in Plantarum succis ex admixtione partium oleosarum cum aqueis copiosiore oritur.* Io. Raius Hist. Plantar. L. 1, c. 5, p. 10.

the Isinglass of the Microscope, to revive, and agitate them gently with a droplet of Oil of the Olive, but regardless of how much diligence I employed, I could not see that they attracted the Oil, or absorbed it, neither that it caused them to unite, but I saw that they all maintained their peculiar bright transparency, and swam freely here and there through the Oil a little less clear than they. Finally it should be added that having pulverized certain Kernels of Wheat of the past year, and soaked this powder for two days in pure water, I placed a little of it on the Isinglass of the Microscope, dispersing it with a droplet of water. The peculiar Vesicles appeared immediately, and turning by chance the Isinglass to the rays of the Sun, I noticed that these passing obliquely through the Vesicles, became convergent, and united in a very bright focus, that was manifested in the water and on the contiguous Isinglass, precisely as would have happened if they had passed through a perfect globe of purest Crystal; because of this there remains no doubt that these Vesicles were perfectly round, almost transparent of Membrane, or full of transparent aqueous liquid. I was not, to speak the truth, the first to discover such globose bodies in the Meal of the Wheat. Count Ginanni [108] testified in writing: *I took sensible experience by the means of the Microscope, of these bright little globes included in the Meal of the Wheat, and of the Barley, and of the other Grains, which have been noted by Leeuwenhoek* [109] *and by others, although this Microscope did not magnify them greatly for me, and perhaps they were clear only to me. It was to me in some sense marvelous, thus to be able, to render all these objects visible, only the clear ones did not appear in the same way to be enlarged. To remove every pretext for doubt, I desired to make use of other Microscopes, and these gave the same effect. I noted in them then also the colors of the Rainbow, when the little globes were illuminated by the rays of the Sun. Each of these little globes is covered by a membrane, that is not of a spherical Shape, but often a little tortuous, and spiral, or Leeuwenhoeck as precisely advises:* I doubt moreover that such an appearance should be referred to these little globes being thin, and rumpled by drying, and to their not having been first provided with water. Of the fact the same Ginanni later writes:[110] *And truly it remains, that the Farinaceous material, which envelops the Germ, and which is an organized part of each Grain, consists of an infinity of little Bodies white and transparent, that cannot be discerned*

[108] Delle Malattie del Grano in Erba Par. 2. cap. 12 § 5. p. 253.

[109] Epistolae Physiologicae super compluribus Naturae Arcanis.

[110] Par. 2. cap. 8. § 9. p. 119.

except with the Microscope, and not without drying up the Grain skillfully etc., and in the Annotation, he says: *And these Bodies are a kind of Tiny Balloon, which being put in motion by the heat of the earth, insinuate themselves in the pores of the germ, distending its parts little by little, and feeding it, until it throws out proper roots for receiving the sap from the soil.* The globules in the Meal have been seen also by M. Aymen,[111] who says: *Le Farine ordinaire de Froment, examiéne au Microscope paroît être composée de corps globuleux, mais ces globules sont sept à huit fois plus petits que ceux du Charbon* (della Volpe) *du même Blé. Les globules de la Farine ordinaire, mises dans l'eau, agissent, et ne se subdivisent pas; les corps globuleux du Charbon, au contraire, mis dans l'eau, agissent, et sont divisés en globules jaunes; donc les globules farineux sont simples; donc une poussière du Charbon est composée de plusieurs corps globuleux réunis ensemble.*

All this I have thought necessary to note exactly, to make it understood, that the little Vesicles into which the Milk of the Wheat diffuses, are not thus accidental, but parts indeed naturally organized, and contained within the sack of the veiling cuticle, which surrounds the seminal leaf, and communicate by means of the very delicate and veiling membranes, woven by the arteries. These Vesicles, as well as I can conjecture, are little bottles, that are full of an oily sap, saline, and spirituous,[112] which fused then with the aqueous moisture insinuated from the outside, serve as the milk, and first substantial food of the tiny Germ, in the first days of its Vegetation, and while it has not yet sucked from the earth, as by means of the roots, a certain quantity of food, and has been able to prepare and digest it sufficiently.[113] Therefore, with all reason the Cotyledons, that is to say the Almonds or polpous and radical Leaves of the Seeds or Plants, are recognized by Philosophers as an equivalent of the Placentas of the Uteruses of many Animals, and of the White of the Egg of many others. Hence, if these radical Leaves are spoiled, or corroded, or cut off, the Vegetation of the Seeds does not occur, or if it does begin, it quickly becomes extinct, and thus is found very true in fact the wise theory of the great Malpighi.[114]

I cannot then truly say, whether these Vesicles are *les Corps mouvans, on en mouvement,* which the very Distinguished M.

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[111] Second Memoire sur les Maladies des Plantes. T. 4. des Memoires de Mathematique & de Physique presentées a l'Acad. Roy. des Sciences par divers Savans. p. 370.

[112] See Hales Statique des Vegetaux chap. 7, p. 272 & 296.

[113] See Hales *Ibid.* p. 297.

[114] Anat. Plant. circa finem. & de Semin. veget.

de Buffon [115] says should be found *dans les Semences des Plantes, dans tous les Germes des Amandes des Fruits, dans le Nectareum, dans les Etamines, qui sont les parties les plus substantielles de la Plante, et qui contiennent les Molecules Organiques necessaires à la reproduction;* or whether they are indeed *les Parties organiques vivantes,* which he has found in different Seeds, and in other parts of Vegetables.[116] It is however certain, that of these Vesicles and of their internal saponaceous substance, everything has been verified that the Great Boerhaave observed to happen in the making of Barley water, or Emulsion of the Seeds of the Almonds, after extraction of the Oil.[117] The milky and greasy substance, which floats upon the watery liquid in the Emulsion, is not other than the saponaceous substance, that is to say the Salt amalgamated, and curdled with the Oil, which exists within the Vesicles, and also many of the same Vesicles wholly entire, as recognized with my Microscope: Removing then all this saponaceous substance, *paucum admodum,* says Boerhaave, *restat in mortario materiae prioris, id autem furfuraceum, macilentum, exsuccum, in aqua solvi per contritum diuturnum prorsus renuens, mere terrestre ferme apparens, omnique Sole carens penitus, neque Olei superstitis signa ulla exhibens.* Such sediment, or Dregs, is not other, in my belief, than the pure Membranaceous fiber composing the Little Vesicles of the Parenchyma, the Arteries of the woven veil that confines it, to the common external very fine involucre that encloses it. The same phenomenon occurs after the vegetation of the Germ is complete, when the seminal placentas have disintegrated, leaving nothing.

Not alone then are the Seeds of the Cereals, those that are furnished with the described Vesicles, constituting the principal substance of the radical Leaf, or Uterine Placenta. All of the other seeds which I have been able to observe, are made in the same manner, and it is reasonable to believe that Seeds cannot be formed without Placentas fashioned in one manner, or in another, and all therefore sufficiently provided with Little Vesicles, or storage places for a saponaceous liquid, substantial, and nutritive.

On the days October 24, 25, and 26, I set out to make a Methodical Observation, upon the internal structure of the pulp of the Seminal Leaves, or Placentas of different Seeds, with my Microscopes, and with those of Sig. Doctor Guadagni. To further my intention, I first held these Seeds in infusion in pure water for two days, and

[115] Histoire Naturelle T. 2. Par. I. p. 252 & 254.

[116] See p. 378. 380. 383. 389. 396. 445. & 448.

[117] Chemiae T. 2. Operat. Chem. Pars 1, in Veget. Proces. 21.

boiled them as much, as is done in ordinary cooking to make them edible, and I saw that this second method is the best, and most certain, for distinguishing clearly the Little Vesicles separately, and very well circumscribed, and without equivocation.

All then of the Farinaceous Pulps of the Frumentaceous Seeds, appeared to me composed of Little Vesicles perfectly globose, a little larger or a little smaller, formed of a delicate veiling membrane, on the outside smooth in seeds in milk (See Fig. 33) and gently wrinkled in well matured seeds (See Fig. 34) somewhat in the fashion of the Crystaloid Herb, or *Ficoides Africana, folio Plantaginis undulato, micis argenteis aspero Tournef.,* and in their cavity full of transparent liquid, which is the water which penetrated from the outside during the time of the boiling, which I noticed caused the Seeds to crack in the cortex or common integument, but not however the Little Vesicles, which are rather hard and resistant, because I have not found them cracked, and have not succeeded in cracking them not even by crushing them between two layers of Crystal, by which artifice they are only flattened and depressed, but not broken. I said such Vesicles were perfectly globose, but it is understood that this is when they were spread on the Isinglass of the Microscope, and disgregated with the help of a droplet of water, for without this help the greater part of them appear mashed at the corners and in some places flattened, and angular somewhat like the seeds or Grains of the Pomegranate.

Repairing to the Frumentaceous Plants, I shall note in the first place that in the Great Wheat, and in the *Gentile* of the race *Dolce,* the Little Vesicles are transparent as Crystal, beheld with bright light reflected from below, but with the light oblique and pale, they appear a little whitened. The membrane which circumscribes them is very thin, and very delicate, with a hint of gentle wrinkling; and all are globose, except when crowded together, and crushed one on top of the other. In the Hard Wheat these Little Vesicles appear to be a little larger, swollen, better circumscribed, and less transparent than in the *Dolce* Wheat. In certain meagre and shrunken kernels of the Wheat from the unhappy Harvest of 1766, the Vesicles were round, small, and somewhat rumpled. In the Barley they were round, a very little bit larger, and more distinct than in the Wheat. In the Oats they were very small, and much more delicate of rind; and much smaller, but they were knotted together in the Tares. The Sicilian Wheat had Little Vesicles rounder, larger, and with Membranes more pronounced than in Wheat or ordinary Grain. The Turkey Wheat in Milk easily showed round Vesicles, very small: mature then and macerated or cooked, it showed them grouped together, in a manner such that it was difficult to disgregate them.

Finally, in the Millet in Milk, I also saw them round, and very small.

The Legumes observed by me, specially the Beans, the Chickpease, and the Pease, when they have been taken, and appropriately in milk, show on the Isinglass of the Microscope the Little Vesicles transparent in green, but with the skin so thin as to be like that of a bubble of air on the surface of water. This skin gradually becomes thicker, to the degree that the Legumes increase in size through the summer, and altogether the diameter of the Little Vesicles increases a little, and their walls become thick and composed of a double membrane, the exterior of which is all very minutely covered with swellings, in the fashion of the surface of the Crystaloid Herb. I happened upon them the first time in Pease fresh, but hard and rather near to being dried to maturity, in which cooked I distinguished perfectly that the Placentas broke up into Little Vesicles of about the size of a Hair, green-tinted, of oval shape but pressed down to that of an Almond (See Fig. 35), with within them a cavity of the same shape, full of transparent liquid, and with the integument or skin all densely roughened with Little Vesicles also of several levels (See Fig. 36). In the dry Pease pulverized, and placed under the Microscope, after having revived them a little, there were distinguished these oval crushed bodies, but a little smaller, in color pale green, and with the integument or little shell thinner, and with swellings less apparent; but upon renewing them with water, they expanded in all directions almost double, and upon being boiled they became equal in size and shape to the ones described above, which I found in fresh Pease. Thus it comes to be understood, how the Pease suck up with such force the water in which they are immersed, and how in the act of sucking it up and increasing in size, they exert an enormous pressure at the top of the vase, and force outward a great quantity of elastic air, as was observed by the Celebrated Hales.[118] Of so prodigious a number are the oval flattened Little Vesicles, which form the parenchyma of the Placentas of the Pease, that swelling however little each one may, wich sucking up the moisture, they must necessarily make a notable increase in mass, and from them must issue with force the elastic air that is nestled among the Little Vesicles compressed, or packed. The Lentils, the Ervums, and the Vetches, also show readily their Vesicles very beautiful, and similar to those of the Pease. Certain white rather large Roman Kidney Beans, sent to me from Valombrosa, had oval vesicles flattened in the fashion of a little pillow, transparent, suffused with lividness, not all however of the same precise size, veined on the outside in low relief, and by

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[118] Statique des Vegetaux ch. 2. Exp. 32. ch. 6. Exp. 57. ch. 6. Exp. 88.

little swellings like preserved Almonds. I observed that the superficial substance of the swellings became detached and stuck to the Isinglass of the Microscope, in the fashion of finely powdered scrapings; and in others I noted that the Vesicles being disgregated with water on the isinglass, there appeared amongst them certain little shreds, or ravels, of the veiling membrane, that must be regarded as a tissue of the Canals communicating with these Vesicles. Certain black Roman Kidney Beans, little cooked, therefore remaining hard when the above described white ones cooked together with them were rendered tender, showed similar Vesicles, but smaller, and these also had the ravels mixed with them. The Kidney Beans of Egypt, that is to say the seeds of the *Phaseolus Aegyptiacus nigro semine C. B. Pin.*[119] also little cooked, had Vesicles smaller, and more elongate than those of the Roman Kidney Beans. The March Bean cooked, and certain other black ones less cooked manifested the oval Vesicles, not all however uniform in size and shape, wrinkled above, or vermicular in relief like the Crystalloid Herb, and left also on the isinglass a finely powdered opaque sequin, which was attached of the skin. I noticed that the Pottage, that is to say *Pulenda* made of Beans cooked and pulverized, for the use of the Common People of Florence, is not other than the very small Vesicles of the Beans, disgregated and uncoupled. Finally the cooked Chick Pease had Little Vesicles similar to those of the Bean, but a little bit more minute.

Also the Pulps of other Seeds not Frumentaceous, nor Leguminous, have the same vesicular structure and substance, as can easily be determined for each with a mediocre Microscope. The fresh Almond, that is to say mature, but not however dried on the Tree, the Kernels in the Stones of the Apricot, of the Peach, and of the Filbert, these also fresh, spread on the isinglass of the Microscope, and dispersed with a little water, were manifestly not other than round whitish Vesicles. One Almond in its superior half was empty, that is to say did not have white and firm pulp, but a certain somewhat mucous material, which prepared on the Isinglass also appeared to be composed of these Little Vesicles, but more delicate, thinner, and more transparent; a sign, I believe, that this was a portion of the same seminal Lobes, or Placentas, aborted, and badly nurtured, as within the membrane of the Vesicles nothing was deposited except water only, or little more. I am pleased to note, that the internal skin of the seed of the Almond, which covers the seminal Lobes, is covered over on all the outside with crowded projections in the fashion of little horns, of halves of Eggs, or Pieces of Sausage, as

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[119] Append. ad Michelii Catal. Plant. Horti Cef. Flor. p. 161. n. 3.

noted already by Malpighi,[120] which are much as Oysters, full of gummy transparent liquid. The skin of the almond of the Peach, and that of the Filbert, are all covered with little hemispherical bubbles; that of the Almond of the Apricot, has transparent semi-ovals, scattered vaguely in the fashion of embroidery; and similar, but more vaguely distributed in the fashion of patches of Brocade, are those of the almond of the Plum. Chestnuts in Milk rubbed on the Isinglass of the Microscope, show at once their oval much flattened vesicles, which appear a very little larger, and gently scabrous in mature Chestnuts cooked by Roasting, or in the Oven, prepared first, and disgregated on the Isinglass. In the examination of a Chestnut tender and in Milk, I noticed that the coriaceous bark, on the internal part which touches the almond, appeared in the form of Velvet with skins white and very thick, which observed with the Microscope, were all little Cylindrical tubes, with a long Cavity, with a little water within, which formed little bubbles there, that upon crushing these skins with the point of a pin, or between two pieces of glass, seem to move up and down, and holding these skins for some hours in water to revive them, I noted that it penetrated, but did not fill them up totally, because there remained some of the little bubbles of air not expelled by the water. The Celebrated Leeuwenhoek in one of his Letters inserted in the *Transazioni Filosofiche A. 1677, n. 136, Art. 5,* says, that the Inner Skin which is found under the first rind of the Chestnut, has two wide planes, but perhaps he saw it in Chestnuts which more than necessary were spoiled, and dry. In seeds of the Cacao not roasted, the Vesicles are flattened ovate, but not all well outlined, for in some places they are crushed one against another, in the fashion of little pillows: permitted however to rejuvenate for some time, after they had disgregated, they swelled a little, and assumed the form of ovate and flattened Vesicles. The seeds of *Ricinus vulgaris Inst. R. H.,* Pine Seeds, the Seeds of the Gourd, and of the Winter Melons, break up into globules round and very small, and upon pressing them between two leaves of Crystal, there are distinguishable various droplets, and sprinklings of Oily substance. Globose likewise, but smaller are the Vesicles, into which the pulp breaks up in the Seeds of the Pear, the Apple, the *Staphylodendron Inst. R. H.,* the *Tithymalus latifolius, Cataputia dictus Eiusd.,* the *Acer Platanoides Euisd.,* and the *Fagopyrum vulgare erectum Eiusd.* Finally the very white Milk of the Seeds of the Jalap, or Jessamine of the night, breaks up entirely into little globes very fine and transparent.

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[120] De Secundis, & contento Plantarum Foetu p. 87. fig. 304.

These are the few observations on the structure of the seminal Lobes, which I have succeeded in making, in some insignificant tag-ends of time, and they have involved me in examining with the Microscope the structure of other parts of Plants also. Among these the sappy pulp of the Breadfruit, appeared to me not other than a weft of Little Cells (See Fig. 37) full of watery liquid, connected among themselves somewhat as in the Cellular Membrane of the Human Body, but with veiling transparent membranes, with certain less transparent fine nerves situated irregularly, and in such manner that one crushes and crowds the ones contiguous. The Pulp of the tender Apple, of the French Apple, and of the Late Apple, is comparable in structure, and is not diversified except in the size of the cellules, which in the Breadfruit are somewhat larger.

After the cortexes of Fruits, there came to me the desire to pass on to an observation of the pulps of Roots. Therefore having cooked upon the Coals a root of Potato, *Solanum tuberosum esculentum Inst. R. H.,* from it I scraped a small portion of pulp still hot on the Isinglass of the Microscope, with a little water, and saw that it was composed of Little Vesicles transparent in the lividness, with thin skin veined on the outside. These having yet to be well infiltrated with water, appeared similar to the grains of the Pomegranate, that is to say crushed, and mashed by contact one with another: as soon however as they sucked up water, and swelled up they appeared like purses, or small pillows globose in the ovate, on the outside minutely granulated. Upon pressing them between two thin flat pieces of Crystal, the majority did not crack, but became larger and flatter; some then manifestly cracked, and they were seen to tear, and to shoot out a transparent oily liquid. These flat pieces then remained all covered with something like fine powdery whitish scrapings, which seemed to be detached in crushing the Vesicles between the flat pieces of Crystal; and certain ravelings were seen also, and Membranous fringes, that probably held collected among them the described Vesicles. A thin slice of the Root of Tame Jesuits Bark held in water to revive, and spread on the Isinglass of the Microscope, dispersed completely into Vesicles round, but inclined to oval, and flattened. In boiled roots of the white Truffle, or *Corona Solis parvo flore, tuberosa radice Inst. R. H.,* the bark separated easily from the pulp, and this pulp which has the odor and taste of the Heart of the Artichoke is entirely composed of little bundles of filamentous fibers, that go from the circumference towards the axis of the Truffle, somewhat like the filamentous tracts of *Pietre Bolognesi,* or like the excretory Little Canals of the Kidneys. These fibers then observed on the Isinglass of the Microscope, and pressed between

two sheets of Crystal, are not other than threads of very small Vesicles, a little flattened (See Fig. 38), transparent in the yellowish, not well defined at the circumference, but similar to soft little pillows, that crowd against each other, or like the rows of Cucurbitinic Worms that form the Taenia in the Intestines of various Animals.

More bizzare is the texture of the Cortical Farinaceous pulp of the Roots of the Sarsaparilla, which when held for 24 hours in infusion in water, then placed on the Isinglass of the Microscope, and disgregated with a droplet of water, appeared woven lengthwise of certain rows (See Fig. 39) like of the Eggs of Fishes crowded close one upon another, with thick structure similar to that of a Sausage, but in such manner that the large part of one row, corresponds to the narrow parts of those at the sides. These Ovaries then are a complex of innumerable round transparent little balloons, not enclosed within a common sack like Eggs of Fishes, but attached to a branched Thread, which serves as an axis for each complex of little balloons (See Fig. 40).

I wished to try also whether in the marrow of the stems of the Plants, there was to be found something similar, and therefore placed to soak in water for 24 hours certain little balloons of *Sago,* which I had kept in my museum, that is to say of the pulp of that species of Palm, which in the East Indies is called *Saguero,* which many years before had been presented to the very Famous Doctor Antonio Cocchi by an English Gentleman, who had come from there. This Sago disgregated on the Isinglass of the Microscope appeared not to be other, than an immense number of large Vesicles almost as numerous as in the Potato, transparent as Crystal, of very thin membrane, in shape tending to oval (See Fig. 41), flattened, but mashed in many parts of the circumference, and somewhat angular, because of the pressure of the contiguous ones and perhaps also from having been too much tormented there in the Indies, in the process of reducing the tender marrow of the Palm into little balloons like to the usual Little Grains. I noted that the greater part of these Vesicles showed in the middle of the layer face certain things, about which I cannot say whether they were round, or whether they were appendixes and hemispherical little bubbles, as with my microscopes I was not well able to ascertain.

I made also some passing Observations upon the Apexes of the Flowers of different Plants, especially Grains, and saw that the greater part of their powders, are globose Vesicles, with very thin membranes, filled with liquid.[121]

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[121] See Boerhaave Elem. Chemiae T. 2. p. 86.

It also is worth stating, that the Milk of the Tithymale, of the Apocynum, and of the Sonchus or Sow Thistle, with the Microscope appeared to me the day July 8 not other, than an aggregation of whitish Vesicles, similar to those of the Milk of Wheat; and such likewise I saw to be the Milk of the Celidonia, or *Chelidonium maius vulgare etc. Micheli H. Fl. p. 25, n. 1.*, which however showed Vesicles of a very beautiful Amber color. Pietro van Musschenbroeck [122] noted on this proposition: *Toutes les parties des fluides grossiers, que l'on peut voir a l'aide du Microscope, ont une figure spherique, comme on peut le remarquer dans le Lait, dans le Sang, dans la serosité, dans les Huiles, et le Mercure. L'Air paroit toujours sous une forme ronde. Lorsqu'on recoit la fumée du Charbon sour la surface d'une verre plat, elle ne represente autre chose que certains globules. Monsieur Derham aiant examiné dans une chambre obscure, sous quelle forme paroissent les Vapeurs, trouvà a l'aide du Microscope, que ce n'etoit autre chose que de petits globules spheriques, qui auroient pu former de petites goutes.* It is proper moreover to state, that the globules constituting the Milks of Plants, and the Animal liquids, are quite different, as I shall have motive for showing when I shall treat of the *Volpe* of the Wheat.

Not only is the substantial saponaceous moisture, collected and deposited within the Vesicles constituting the Parenchyma of the Placentae of the Seeds, necessary for the Vegetation, and early nutrition of the tender Embryos of the Plants, but it is likewise of very great utility for the nutrition of the Animal Body, and in Part VI I shall make this better understood.

It is appropriate now to make some reflections on the mode, with which the Rust nestled in the stems of the Wheat, can steal the food from the Kernels of the Seeds, and consume it, although it is remote from them. Sig. Francesco Colono Roman Gentleman dwelling in Paris [123] has with diligence set forth Observations, that the Kernel of the Wheat is formed by the continuation, and by the prolongation of the arterial Vessels of the stalk, which changing direction at the base of the chalice, and varying in caliber and in situation, become adapted to form the Seed, with the Germ, and with the Placentas full of Vesicles, by being filled gradually with saponaceous substance. By this same Mechanism are formed, and nurtured the seeds of all other Plants, as Sig. Colonna proves; therefore the consequence is obvious, that whenever the arterial Canals of

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[122] Essai de Physique T. 1. ch. 20. § 698. p. 367.

[123] Histoire Naturelle de l'Univers T. 3. p. 148 *et seq.*

the stem of the Wheat are torn, stopped up, and rendered useless by the Rust, in such manner that by means of them food cannot rise to the seeds, the seeds must remain meager, badly nurtured, and morbid, as indeed we have seen happen in 1766. The Philosophers doubt whether there is, or is not, circulation of sap in Plants;[124] but if the Rust stops up and renders the arterial Vessels, useless, the corresponding Veins would as a consequence remain useless also. The younger, and more tender the stem of the Wheat, the larger in caliber, and more delicate of wall are its arterial canals, although greater rise of sap towards the Ear occurs through them. Therefore, if the Rust is born too soon, and before the seed is full, and stagnant, it will irreparably atrophy the seed, by stealing the food along the way. The worst is that the time is too long, in which the seed of the Wheat runs the risk of being consumed by the Rust, which arrives as thus specified by Columella:[125] *Omne Frumentum, et Ordeum, quicquid denique non duplici semine est* (that is to say has a single seminal Leaf, or conglobate Placenta) *Spicam a tertio ad quartum nodum emittit, et cum totam edidit, octo diebus deflorescit, ac deinde grandescit diebus quadraginta, quibus post florem ad maturitatem devenit. Rursus quae duplici semine sunt, quod maceratum, vel Terrae mandatum in duos lobos satis distinctos abit, ut Faba, Pisum, Lenticula, diebus quadraginta florent, simulque grandescunt.* N. E. Tscharner [126] states that a *Plant attacked by the Rust, loses insensibly its nutritive sap, lags behind in its enlargement, and dries up. In proportion that it is early, or that it acquires consistency early by some accident, it produces more or less perfect seed. Among these occur certain Grains light, imperfect, wrinkled, called* Bleds retraits, *and* Echaudés; *but this Malady can arise also from other causes. The Straw moreover because of the Rust, loses all its value, if not taken care of by cutting immediately that the malady becomes manifest, and is not in condition to give good nourishment to the Cattle.*

However easy God willed it to understand the nature, and the evil effects of the Rust, that easy would it be to keep the Rust far off from our Countryside, and bless the race. *Rubigo maximo segetum pestis,* Pliny [127] allows himself to write *Lauri ramis in*

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[124] See Ginanni delle Malattie del Grano in Erba p. 329. n. 360. Charles Bonnet. Recherches sur l'usage des Feuilles dans les Plantes Mem. 5. § 92. p. 276.

[125] De Re Rust. L. 2. c. 12. p. 438.

[126] Memoires & Observ. recuellies par la Societe Eoconom. de Berne. Année 1764. 2. Part. p. 32.

[127] Hist. Nat. L. 18. c. 17.

arvo defixis, transit in earum folia ex arvis; and similarly there is bequeathed in the *Geoponici Greci:*[128] *Prodit Apuleius si Lauri ramos in arvum proieceris, transire in ipos Rubiginis noxam.* If this were true, as is not our misfortune, Tuscany, where over the greater part the Laurel Tree reigns most beautifully, would have an easy and quick remedy; but without trusting this it [129] is better to seek one that is safer.

The Abbot of Vallemont [130] states: *on dit encore, qu'un nommé Mons. Paquer connoit aux épis, lors qu'ils sont en Fleur, ceux qui ne sont pas sujetes à être brûlés d'une certaine broiiée, qui les grille; il les remarque, et les reserve pour les semer.* I however have not elsewhere encountered such a rule, which if it proves true in practice, would be easy, and perhaps with diligent observation would be confirmed.

There is the proposal of making certain preparations for the Wheat to be sown, and the allurement that they would be useful in preserving Plants from the Rust as they grow. *On raconte,* says the same Vallemont, *que dans la province de Chechir en Angleterre, afin d'empêcher ce grillement du Blé, on laisse celui qu'on veut semer 24 heures dans de la saumure, avec la quelle on mêle aussi du Bol; puis on le seme au meme instant. Outre cela, ce secret empêche encore que les Oiseaux ne le mangent.* Home [131] says it is *a fact for a long time observed, that the Wheat becomes stronger, that it germinates more quickly, and that it is less subjected to the Rust, when it has been immersed in liquors that contain Salt, and Oil, like the water of the Sea, Urine etc.* Another preservative is proposed by Count Ginanni [132] in these terms: *I conjectured, and with my experiments ascertained, that a good preservative against the evil effects of the Vapors, would be a thick lye bath of Black Grain (that is to say Volpato) well calcined, and pulverized, united with Salt of Tartar, and in this immersing the Wheat for an entire day before planting it. The combination of these two Salts is such, that it becomes capable by chance of absorbing strongly the same vapors, when they are attacking the Wheat.* I do not know how much such preparations can be counted on, after it has been seen that the seeds of the Rust are scattered in great quantity through the soil, and through the air,

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[128] L. 5. c. 31.

[129] See Ginanni Par. 4. c. 1. § 2. p. 368.

[130] Curiositez de la Nature & de l'Art sur la Vegetation T. 2. p. 127.

[131] Principj dell'Agricultura Par. 3. Sez. 1. p. 73.

[132] Par. 4. c. 1. § 6. p. 370.

and very few of them are by chance attached to the seeds of the Wheat.

For the same reasons, it appears that the Secret proposed by Berizio [133] is little to be trusted, that is [to say]: *Quin et per naturam contraria affectione resistit, se in Cribro Phocae pellis circumponatur perforeturque, ita ut per Cribrum semen excutiatur, et terra conseminetur. Hoc idem et Grandinem cadere non finit, naturali quadam contrarietate auxilians.*

Columella [134] thinks that something better is indicated, where treating of the rule in use in weeding the Wheat, and the Oats, he says: *aliae segetes,* except the Lupine *quae vel humidae moveri possunt, melius tamen siccae sarrientur, quoniam sic tratatae non infestantur Rubigine.* I have hinted, something about the great benefits, the Wheat Plants receive, and the Oats, from Weeding, because of which it happens, that they take root much better, and become reinvigorated, so that when the season appropriate for the Vegetation of the Rust arrives, these Plants are found consolidated, and advantaged in maturity, and they suffer less damage from it.

It has been judged the best remedy for the Rust, says Ginanni,[135] *in which opinion I agree very willingly, the extirpation from the midst of the Grains, the heterogeneous herbs, and any other Herbs than those of the Wheat, or to remove the earth about the same, because then the Dew adheres to the spike with more difficulty when shaken by the light Wind. In many places of my Observations I have made use of this remedy, and there I have then found indeed Worms, Soot, and other Maladies but the Rust almost never.* It was noticed moreover, that in the course of the year 1766, the Rust had caused deplorable ruin, especially in the vast and opulent countryside of Maremma, where because of the great scarcity of inhabitants the Wheat could not be cleaned of Weeds, which were in very great abundance; while on the Farms in the vicinity of Florence, where with very great eagerness the Countrymen collected all the Weeds that ever they could find mixed with the Grains, refined to serve for fresh pasturage for the Beasts, or for drying and preserving for the Winter: and they were fortunate in finding them in great quantity, to supplement their Straw of which they had a great scarcity. On the other hand it is considered, that in this same year the *Vecciati,* that is to say the Grains sown and grown along with the Vetch, were immune from the Rust, contrary to

[133] In Geopon. Graec. L. 5. c. 31.

[134] De Re Rustica L. 2. cap. 12. § 5.

[135] Par. 4. c. 1. § 10.

Count Ginanni's rule, although the Vetch was able to produce great foliage, and although in the vast Possessions of the Valdinievole, other Herbs mixed with these *Vecciati* could not be taken away.

If it would be as easy, Ginanni [136] proceeds to say, *and cost as little as it would be safe and certain to grease the Spikes with Oil, I should believe this a great remedy, for preventing the harmful Dews;* but this would not be possible to do except in a small Field, and I fear that the Oil stopping up the inhaling vessels, and those exhaling of the Spike, could cause great damage.

But in order that (is an Observation of the same Count Ginanni [137]) *the pernicious exhalations of the Marshes may not contribute to the formation of the Rust, I have always believed well proved, that a large Ditch should be dug in the vicinity, through which the putrid water continually is led away, and the pure water enters, and mixes with it.* Also this cost and diligence would come to a frustrated end, because it was seen in the course of the year, that the Fogs and the Rust affected equally the Countrysides of Maremma, of Pisa, and of Chiana, contiguous to the Marshes, and those of Florence, and other places, very remote from them, and even those high and dry on the Hills and Mountains.

Ginanni adds this: *But if it were practicable, as Abramo Monting thinks, ought to be done to Trees, to defend them from the cold nocturnal Dew, to wet the Oats every evening, when they are burning, I believe that it would be profitable also against the pernicious vapors.* At the time when the Rust manifests itself humidity is never wanting in the Ground, and in the Atmosphere, rather the excessive humidity assists the Vegetation of the Rust; and therefore I would not count much on watering the Oats, which would not be possible to do except in little Fields.

Says Theophrastus:[138] *si copiosae Pluviae fuerint, Rubigo nulla consistit, diluitur enim, atque detergitur,* which was found true also by Count Ginanni.[139] This probably depends, on the fact that the shock of the Rain washing the stems of the Plants, carries away, and causes the little seeds of the Rust to fall to the ground, and does not permit them to become enchased within the little mouths of the absorbing vessels. Perhaps also the Rains by supplying more copious food to the Plants, cause to be felt less the damage from the food, of which the buds of the Rust rob them. If it were proposed to protect a single small Field of Wheat from the

[136] § 11. p. 372.

[137] Par. 4. c. 1. § 7. p. 370.

[138] De Causis Plantarum L. 4. c. 15.

[139] Par. 2. cap. 3. § 13. p. 72.

Rust, it would be possible, immediately that the Rust is perceived to have appeared in it, to water and wash the Wheat with Garden Watering Pots; but in vast possessions this is not executable, and it is possible to desire, but not always possible to have Rain at once and obedient to our needs.

Segetes, notes the same Theophrastus,[140] *vento expositae, minus Rubigine infestantur, motus enim humorem discutit; nam et cum post Imbrem flatus secutus, et nox deinde successerit, Rubigo minus consistit, flatus enim humorem deiicit, et Sol paululum immoratus putredinem nullam conficit, sed prius quam quidquam emarcescat, humor totus exsiccatur, atque absumitur.* It is easily understood that the Wind, when, by good fortune, it begins to blow immediately after the falling of the injurious Dews, purges and changes the Atmosphere and shakes off and dissipates the droplets of moisture lying attached to the stems and to the Leaves of the Wheat and the Oats, and also shakes off and casts upon the ground, or carries away to a distance, and dries up the little seeds of the Rust, not permitting them to be able to implant themselves and germinate. On this theory appears founded the rule proposed by various Writers, that is to say of the shaking off promptly of the injurious moisture of the Dews or Drizzles, without allowing time for it to remain upon the Wheat and the Oats, and foment the development and the Vegetation of the Rust. The easiest way which the various Authors [141] indicate for shaking off the injurious moisture, is that two persons, early in the morning, immediately that the deposited evil Dew has been perceived, go up and down through the fields, according to the direction of the Furrows, with a rope, of which each should hold an end, and trail it along upon the backs of the Wheat, and the Oats, so that the weight and the shock of this rope, shakes off the moisture of the accumulated Dew. Count Ginanni [142] has performed this shaking, with a little bundle of very thin willow twigs. Such diligence should be safe and efficacious, and I think that they practice it in some parts of the Province; but using it in vast Possessions, they would not be able to operate with suitable promptness, especially if the indolent Countrymen do not have just love for the goods of the Patron. At least, it ought to be practiced in the lower Fields, and deep in valleys, where ordinarily the Rust is known to cause the greatest ruin.

Another easy, and safe, remedy is proposed, for dissipating the damaging Fogs from the Inflorescence and Husks of the Wheat, and

[140] De Causis Plantarum L. 3. c. 27.

[141] See Vallemont Curiositez de la Nature & de l'Art sur la Vegetation T. 2. p. 127.

[142] Par. 4. c. 1. § 9. p. 371.

the Oats, and hindering the Vegetation of the Rust. Columella [143] treating of the Vines, says: *Palearum acervos, inter ordines, tempore positos habeto in Vinea, cum Frigs contra temporis consuetudinem intellexeris, omnes acervos incendito, ita Fumus Nebulam, et Rubiginem removebit.* Also Palladio [144] informs: *Contra Nebulas et Rubiginem. Paleas et purgamenta pluvibus locis per Hortum disposita, simul omnia, cum Nebulas videris instare, combures.* Pliny similarly [145] writes, that there this gives some remedy for the Rust, that is to say: *Sarmenta aut palearum acervos, et evulsas herbas, fruticesque, per Vineas Camposque, cum timebis, incendito, Fumus medebitur. Hic e Paleis, et contra Nebulas auxiliatur, ubi Nebulae nocent.* The same thing is asserted by Agostino Gallo, by Carlo Stefano, and by Chambers cited by Count Ginanni.[146] *Quidam tres Cancros vivos* (the same also would have been dead) *cremari iubent in Arbustis, ut Carbunculi non noceant. Alii Siluri Carnem leviter uri a Vento.* In the Geoponicis Grecis [147] it is said: *quidam Silurum Piscem concisum urunt secundum Ventum, per omnem regionis partem odorem spargentes, ut per totam Vineam Fumus dispergatur.* Diofane [148] informs, *Stercus aridum per diversa spatia in Vinea deponito, secundum Vineti Ventum, et ubi incumbentem Pruinam videris, Stercus succendito: Fumus inde elatus Pruinam dispergit.* Berizio likewise [149] says: *Simul ut videris Rubiginem in aere congregari, statim Bovis cornu sinistrum* (I believe that the right would have had equal virtue also) *cum Bubulo stercore urito, et Fumum multum per ambitum arvi, secundum Ventum facito, quo Ventus omnem Fumum ad Rubiginem, ferat, disperget enim omne Aeris vitium Fumus. Apuleius tradit trium Cancrorum ustorum cum Bubulo stercore, aut Paleis, aut Stercore Caprino, Fumum sufficienter iuvare.* The theory of such operations, is to pour into the Atmosphere saline exhalations, and volatile sulfurous ones, to set free and set in action new elastic Air, and to arouse a motion intestine, and rarefactive among the particles of the air shocked by the sparks, and by the sooty exhalations, whence there follows a useful and salubrious alteration of the Atmosphere. It is necessary moreover, that this

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[143] De Arboribus c. 13.
[144] De Re Rust. L. 1. c. 35.
[145] Hist. Nat. L. 18. c. 29.
[146] Par. 4. cap. 1. n. 403. p. 358.
[147] L. 1. cap. 31.
[148] *Ibid.*
[149] *Ibid.*

Fumigation should be made with judgment, and with burning material that will not pour into the air exhalations too saline, or caustic, which would bring about then for other reasons damage to tender Plants, mostly when they are in Flower. At c. 482 of my *Ragionamento sopra le Cause, e sopra i Rimedi dell'Insalubrità d'Aria della Valdinievole,* I have cited various Authors, who explained how the Fumes of various substances could harm the Countryside, and Count Ginanni states:[150] *After I had burned some bituminous material several times in bundles in a field of Oats, I had reason to remain assured, that the leaves exposed to the vapor carried to them by the wind, in a little time became corrupted, and finally dried up. But the heat of the vapor exhaled by the materials that burned, could not produce this effect, being at too great a distance; hence it seems, that it ought to be attributed to the action of bituminous particles upon the air contained in the Leaves, which fixed the elasticity: and of this nature could be said sometimes to be the Vapors, which produce the Fogs and pernicious Dews.* Also, the Celebrated Pietro von Musschenbroeck,[151] after having accented the council of Pliny as above reported, adds: *Je ne conçois pas que cette Fumée puisse produire aucun bon effet, si ce n'est dans les endroits où il y a des Vapeurs, et des Exhalaisons Acides, qui se trouvent alors temperes par ce qu'il y a d'Alcali dans la Fumée.*

Si anticipet Rubigo, says Berizio,[152] *damnum resarcies hoc modo. Cucumerum Sylvestrium, aut Colocyntidis radices, aut folia contundito, et aqua macerato, indeque apprehensa a Rubigine irrorato, ante Solis exortum. Idem facit cinis Ficulneus aut Quercinus maceratus, et irroratus. There are those who believe,* says Count Ginanni,[153] *that remedy against the Rust can be achieved, from sprinkling the Wheat in Herb with Tobacco, or with Pepper, but this does not correspond with experiments made by me three times. Many times I have cast among the Wheat in Herb, in the month of April, bits of Cloth, and Flannel, and other things, soaked in a strong solution of Salt of Tartar, or Sea Salt, or good Acid of White Wine, and well drained, according to the instructions of Hales,*[154] *to guarantee the evil effects of the vapors, and to suffocate the air, but I would not be so bold as to affirm that*

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[150] Par. 3. c. 1. § 12. p. 303.

[151] Essai de Physique ch. 39. § 1354. p. 761.

[152] In Geoponicis Graecis L. 5. c. 31.

[153] Par. 4. c. 1. § 3. and 5. p. 369.

[154] Statique des Veget. p. 223.

they were ever of benefit, many equivocations often having been found: and who knows that such sprinkling of materials charged with salines, do not prove unhealthy and prejudicial to the tender Plants of the Wheat, and the Oats, especially while they are in Flower, and in Milk?

N. E. Tscharner [155] treating expressly of remedies for the Rust, says: *As far as I was able to note, the Swiss Countrymen up to now have not known any other preservative against the Rust, than to cut all the infected Wheat, immediately that the sickness manifests itself, with the hope of saving by this means all the remainder of the Field. Although to me it appeared that in this they deceive themselves, this does not deny that this practice has several advantages. Primarily the place where the Wheat is cut, can be worked, and employed for cultivating other Plants, such as Maize, or Indian Corn, Turnips, etc. Secondarily in this manner there is saved at least the Straw, which has not been ruined. 3. The Countrymen thus destroy a great quantity of Insects, that would have multiplied, and infected other Plants. Moreover the more experienced and enterprising Cultivators, have sought other remedies, and have succeeded felicitously in their attempts, to find some manner at least of preventing, if not of destroying such disease. As therefore the Rust proceeds from the later Fogs* (or becomes manifest after them) *which often arrive a short time before the Reaping, and sometimes also when the Wheat has reached a certain degree of maturity, although at that time the effects of the Rust would be less damaging; some intelligent Cultivators have sown with success the* Espautre blanche, *that is to say Spelt, rather than the red, because it always matures eight or ten days later than the other. A second precaution is to sow thinly, because the rust makes greater ruin of and attacks more severely the weak Wheat than well nurtured Plants; a thing which has been observed also by different Countrymen in other Countries. The one and the other of these reflections prove also that it is well to sow early, because the Wheat thus grows more vigorously, and matures more quickly. Because then old Wheat, that is to say of a year, is drier, and more healthy than the new, and produces stronger and healthier plants, a Countryman of the environs of Thun has experienced it to be the optimum precaution against the Rust, to make the*

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[155] Memoires & Observations recuellies par la Societé Oeconomique de Berne A. 1764. 2. Par. p. 38.

Sowing rather with old Wheat, than with new. We have also been able to note, that a Field fattened by the Brulis, *or with Ashes, was in truth attacked by the Rust at the same time as Fields nearby, but resisted better and for a longer time the progress of this Malady. It is agreed then to prefer a government dry and hot, to macerated and cool muck, above all in low and damp Fields. Sandy Marl, Ashes, burned Soil, Lime, Manure as of Horses, of Goats, etc., are the best governors of soil of this kind.* All rules suffer some exceptions. Sig. Doctor Bernardino Vitoni Most Learned Physician of Pistoia, in his letter of September 14, 1766, thus writes to me among other things: *The Late Wheat has been damaged more than the Early; more on the Plain, than on the Hill; even at Lamporecchio there was the greatest harvest of all the Pistoiese Territory; and in one of my Manors completely shaded, where little can come, through the many Fruits that cover it, there was a sufficient harvest of very good Wheat. In the beginning I observed whether Insects were to be seen, but could not see others of them than the usual ones of the past year, although in less quantity, considering that that year there had been a scarcity of every sort of Insect. Some cut the Wheat as soon as it was attacked by the Rust, to make sure, as the Countrymen believe here, that the Rust would not consume it, but for them it became much worse.* I have intended to say, that also in other parts of Tuscany, there have been those who cut the Wheat, immediately that they have discovered the Rust, with the idea that it would recover and ripen in the Rick; but for some it worked well, for others badly; I believe because of different degrees of maturity of the Wheat, which if it is well nurtured and perfected, can become ripe in the Rick when cut a little immature and green. In the month of March of this year that Wise Man our Philosopher Sig. Abbot Giovanni Lapi, published a *Metodo sicuro per destruggere i Succiameli, con alcune Riflessioni d'Agricoltura,* in which at c. 77 there may be read certain of his most prudent *Reflessioni sopra le Raccolte de' Grani Rugginosi.* There the Readers will be able better to satisfy themselves upon some points accented by me, and will admire all the more the knowledge, and the zeal of Sig. Abbot Lapi, who makes us expect, and desire more than less his useful speculations on the materials of the Countryside.

It is time now after so long a discourse on the Rust, to pass to a description of other sections, or Races of Microscopical Parasitical Plants, which truly do not cause so general a Death as does the Rust, but with the ruin which they do cause to the Seeds only of

Cereal Plants, they often become a formidable scourge of our Countryside. The second section then, and Race of Microscopical Parasitical Plants, comprises those that are born and vegetate solely within the tender Kernels of the Culmiferous Cereal Plants, and convert into appropriate substance all that food, that would be employed for nurturing and enlarging the Kernels.

Repairing therefore to the *Volpe* of the Wheat, I shall say that it is known generally in Tuscany by this name, and is found noted in the Dictionary of Crusca, although our Botanist Domenico Vigna [156] confuses it with *Grano Annebbiato*. Count Ginanni [157] describes it under the name *Grano Carbone,* and says that in Lombard they call it *Fama,* or *Fama nera,* and in Piacentino *Marzetto,* believing there that it begins in the month of March, and therefore is like a rot of the Wheat; in Milanese they call it *Grano Negrone,* and in Modanese *Mortella*. The French call it *Nielle,* and *Bled Nielle,* or *Bruine,* or *Charbon*. Sig. Duhamel calls it *Bosse,* or *Charbon,* and Sig. Tillet *Bled cariè*. Count Ginanni took many pains, to investigate the true nature of the *Volpe,* but did not succeed well, and only left many exact observations, that shed light [158] specially upon the symptoms of the Plants, in which are discovered the Kernels *Volpati,*[159] which more commonly are those of the *Gentile* Wheat, or *Triticum hybernum aristis carens,* since up to now it is not known to have taken root in the Great Wheat, or *Triticum Aristatum*. The first tuft of the eighth kind of Rust, which I found the morning of June 18 in the interior of a glume, beside a kernel of Wheat *Volpato,* made me desire to examine the Kernel. It was very much larger than certain others not *Volpati* of the same Ear, with the skin of a color externally deep green, and much thicker, and within whiter, and upon being handled emitted a fetidness as of heated Fish. By the signs which are constant, it is easy to distinguish the Kernels *Volpati,* from the healthy that are in milk or in wax; but when the Ear has ripened, the Kernels *Volpati* are smaller than the healthy, and with the skin wrinkled and of an ashen color, and they will float in water. Internally then the Kernels of Wheat *Volpato,* as well when fresh, as when dried, are full of a black very fine powder, every molecule of which maintains one same and equal Shape of a little globe, companions precisely of those of the above described eighth kind of Rust, that is to say (see Fig. 42) not smooth, but

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[156] Animadversiones in Theophrastum p. 7. & 21.

[157] Delle Malattie del Grano in Erba Par. 1. cap. 3. p. 30. Tav. 3. Fig. 1.

[158] See delle Malattie del Grano in Erba Par. 1. cap. 3. Par. 2. cap. 7. Par. 3. cap. 3.

[159] See pp. 95 to 109.

with 12 swellings or little knobs that present to the eye the Shape of a Rosette, or of a button of Brilliants, and differ solely from this Rust by their Color, not yellow, but black, and in that under the Microscope they appear transparent and pale, like certain occidental Topazes. These little globes of the *Volpe* are moreover viscous on the surface, and within are also full of a liquid, which issues out if they are pressed between two layers of Crystal, and without there being distinguishable absorbing orifices, they take in liquids introduced at the outside. Pure water, and Spirit of Wine, cause them to change in shape to that of a sphaeroid surrounded by a cracknel (see Fig. 43); but they absorb the Oil of the Olive better than any other liquid, and they swell finally to the point of becoming yellowish little vesicles (see Fig. 44). Upon pouring a droplet of the Acid of Lemon beside a little mound of the *Volpe*, I noted that it attracted all of them with great velocity, and with a kind of effervescence, but did not cause other changes in the shape of the little globes, except that it caused vague Rosettes to appear. No matter how scrupulously, nor repeatedly we would make observations upon the globular Rust of the eighth kind, and upon the *Volpe* of the Wheat, with the very sharp Microscopes of Sig. Doctor Guadagni, and also with the Solar, we could not recognize even the least difference between these two organic substances, except the color, and the odor issuing only from the *Volpe,* not from the Rust, which it would appear to me resides rather in the skin of the Kernel, than in the black internal powder. It should be added that I tested by burning the dry Kernels of the *Volpe,* holding them with pincers above a flame, and allowing them to burn so that finally they burst into flame, which was followed by explosions of the many elastic airs, and without notable fetidness, in the least different from that of the healthy Wheat, which in burning expels much more elastic air. It is therefore worthy of being said, that the powder of the Kernels *Volpati* after being carbonized, beneath the Microscope, appears not to be other than the same little black globes, which they were before having been burned, and of precisely the same shape unswollen, except that in mass they are a little bit smaller, and certainly this is surprising, that little bodies of a texture so delicate, should have borne up so well under the destructive force of the Fire. Only is it notable, that when crushed between two layers of Crystal, it was seen that there was pressed out a certain oily and limpid moisture, and a little globule was seen very clearly split as if to the bottom into two concave little shells. The Kernels *Volpati* after being thus reduced to Carbon, upon being cut through the middle with a Pen-knife, showed a black uniform paste, not shining, and stank of empyreuma, while the carbonized kernels of

good Wheat, harder, shining and somewhat vitreous within, and under the Microscope their powder was not other than irregular fragments. I have not succeeded in discovering on the little globules of the fresh *Volpe*, anything except very tiny remnants of stalks, or very slender stems, but I succeeded in seeing some of them the morning of June 30 on the dry *Volpe,* formed like knots, whence it could be concluded without fear of mistake, that the *Volpe* is a parasitic little plant, similar to the eighth kind of Rust, and indeed the very same, that is born and vegetates within the tender embryo of the Wheat, and of other Cereal Plants, sucking up and appropriating the nutriment that ought to be carried to the embryo. There was taken in vain all the most scrupulous diligence, to find out whether in the globules of the *Volpe* we could discover any sign of life, or of animal movement; and it was the more important to do this, since it is known that M. Duhamel was not far from thinking that the *Volpe* is the work of Insects,[160] and Needham [161] affirms having found within it Little Anguilliform Worms, and certain little red Worms were observed internally in the beards of the Wheat *Volpato*.[162] Count Ginanni moreover, did not find any indication of any Animal.[163] I ought not dissemble, that M. Tillet, for the same Ginanni [164] notes as much is assisted by the globular shape of the powder of the *Volpe,* and its resemblance to that powder into which is united almost all the overripe pulp of the Lycoperdons, or we may wish to say of the Puffballs, mostly of the *Lupaie*. I have examined with the Microscope different powders of the Puffballs that I have in the series Micheliana, and I have found that they are all spherical Little Bodies, similar it is true in size, and in color to those of the *Volpe,* but all, more or less, spiny in a certain manner, that is to say furnished on the surface with slight hairs, or little spurs, on the order of the Apexes of certain kinds of Malva, or rather like the Husks of the Horse Chestnut, or like the Fruits of the common Stramonium.

The day October 23 in the my Garden for the Repose of the Aged I found certain ordinary old canes, adopted to support the Vines, spotted here and there with black: of them I took a piece, and the next morning upon scraping onto the Isinglass of the Microscope a little of the black very fine powder, which was in great supply in certain cracks, and rejuvenating it with a droplet of water, I saw to

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[160] See Charles Bonnet Recherches sur l'usage des Feuilles dans les Plantes Mem. 5. § 102. p. 329.

[161] Nouvelles decouvertes faites au Microscope.

[162] See Ephemerides Academiae Naturae Curiosorum A. 1691. p. 324.

[163] P. 2. c. 7. § 18. Par. 3. c. 4. 8.

[164] P. 30. p. 51.

my great amazement, that it was not other, than globose knobby Little Bodies, similar in all and for all to those of the *Volpe* of the Wheat already described; upon turning this Isinglass towards the Sun, in the circumference and in the swelling of these little globules there appeared very pleasing Rainbows, and very bright. This observation merits being repeated with greater convenience, and with more perfect Microscopes, to make it clear whether such Little Bodies are truly the same thing as the *Volpe* of the Wheat, or else another class of very small perennial Plant, which in the fashion of the Lichens, uses the surface, and the fissures of the dead and dry Cane for a mere base, and draws its nutriment only from the moisture of the Rains, and of the Dews, since from the substance of the dead Cane, in which occurs no more motion, or circulation of liquids, it would not be able to steal food.

To understand the generation of the *Volpe*, would it be possible to suspect, that the natural milk-bearing Vesicles of tender Wheat, described earlier because of disease degenerate into the black little globules constituting the *Volpe?* I cannot induce myself to believe it, because I have ascertained, that the little globules of the *Volpe* are in all and for all, with the single exception of color, similar to the little globules of the Rust of the eighth kind, which vegetates also outside of the kernel of the Wheat, and upon many other very different Plants, where milk-bearing Vesicles are not found. Rather I would believe that the *Volpe* is also a parasitic Little Plant, if not the same precisely as the Rust of the eighth kind, at least very similar; and that one of its seeds of imperceptible smallness, scattered by the air, and implanted by chance in the apex of the embryo of the Wheat, where stand the two tubes formed in the fashion of a feather, and through which the volatile fertilizing substance of the Apexes penetrates into the embryo, there it being implanted, grows, and enchasing the radical fibers of its base, precisely in the little apertures of the canals destined to carry food to the embryo of the Wheat, it takes as property, and usurps, so to speak, this food, and causes the embryo to die of hunger, fattening and increasing at its expense. To me the theory seems more likely, of considering that the Bran, or rind of the Kernels *Volpati,* enlarged notably, and being distended, much more than that which is formed by other Kernels of the same Ear not *Volpati,* as I have seen happen in some human Embryos, which being dead in the first week of their life, without the Placenta being detached from the Uterus, food has continued to pass into the Placenta, and into the afterbirth, and caused it to grow and enlarge in such a manner as to become a Fleshy Mass. So many times one finds the Almonds of divers empty Fruits, filled with a morbid substance, but with only the aperture

sealed up and sufficiently nurtured; and the Wheat standing bewitched, so to speak, in the year 1766 by the Rust, has its Bran all entire, and sufficiently nurtured, as is recognized when attempting to revive it in water; but within it does not have even the fifth part of the pithy substance, and Farinose, that it ought to have naturally.

Levino Lemnio [165] says, that in the Lightning *inest vis pestifera, ex qua spiritus venenatus in contacta diffunditur, eoque fit, ut a Fulmine adustis teterrimus odor emanet, quod in Aristis confricatis, percipimus, quae tactu Fulminis Robigine vitiate, sulphureum odorem naribus offundunt.* It would be impossible to say whether by this ought to be understood the *Volpe,* or the *Carbonchio,* since with both of these maladies the Ear emits a fetidness very unpleasant, which does not happen with the Rust. Natale Chomel [166] notes, that the time when the Grains are most subject to the *Volpe,* or *Nielle,* or *Bruine* as he calls it, is from the middle of May until the time of Cutting, and believes that it is provided by Fogs loaded with greasy exhalations, which are deposited on the Wheat, and become then reheated, and dried out by the rays of the Sun; and of the same sentiment are Pluche, and Carlo Bonnet.[167] Tull thinks, that excessive wetness of the ground is the cause of the *Volpe,* but he gives no support. M. Duhamel du Monceau [168] has furnished many good observations on the *Volpe* of the Wheat; and especially he notes, that it abounds in years, in the which the Springtime is cool, and humid, especially if cool Rains dominate, when the Ear is formed, and the Wheat flowers: and also in Lombardy it is commonly believed that the abundant Rains of March are causes of the *Volpe.*[169] M. Aymen [170] has made many beautiful, and instructive observations on the *Volpe,* which he calls *Carbon, ou Bled noir, ou Grain-Charbonnè,* from which he believes it ought to be concluded; 1. that the Sap (*la sevè*) of Plants contains many globular bodies. 2. That the nutritive sap of many Vegetables becomes black, in the measure that the globular bodies approach, and united one with another. 3. That the globules of the sap (*de la Séve*) have an essential character, that distinguishes them, and it is their mass, and their shape.

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[165] De occultis Naturae miraculis L. 2. c. 48.

[166] Dictionaire Oeconomique T. 1. p. 336.

[167] See Ginanni par. 3. c. 3. § 8.

[168] Traité de la Culture des Terres cap. 17. p. 224.

[169] Ginanni Part. 3. c. 3. n. 362.

[170] Second Memoire sur les Maladies des Blés. T. 4. des Memoires de Mathematique & de Physique presentées à l'Acad. Roy. des Sciences par divers Savans p. 365.

4. That the powders of the *Carbonchio,* and of the *Volpe* have globular bodies, that have the same mass, and the same shape as those that are discovered in the Sap (*dans la Séve*): they are therefore he says, of the same nature; hence they come from the Sap *Séveux. I have taken,* he says, *the Sap of Birch, and of Walnut, have placed it in a concave objective glass of the Microscope, and there I have seen with pleasure many little globular bodies such as has been noted above, that move in many directions. I have seen the same thing in the Sap, which I have extracted from the Leaves and the Roots of the Turnip, Dog's Grass, and Cane. Indeed many times before these globular bodies had been observed by me moving in many infusions of Plants. I have split Kernels of Wheat, Barley, and Rye, which I had soaked a long time, and after having placed them under the Microscope with some droplets of water, I have seen that the longitudinal fibers become bleached, contorted, and allow yellow globules to escape, which come to the surface of the water, moving in all directions. M. Buffon has seen the same globules in the Seeds of the Violet, Hill in infusions of the Seeds of a Plant, Needham in infusions of the Almond. He has seen in infusions of pulverized Wheat, vegetations that were composed of five and six globules in the form of little garlands.* In the Italian Language I do not find terms sufficient to distinguish *Suc* from *Séve:* I believe however that *Suc* properly would be the general mass of the aqueous and nutritive liquid, which rises upward through the canals of the Plant, which is very thin, and passes through canals of a fineness imperceptible, and in which, even with very acute Microscopes, with difficulty tubular cavities are distinguished, and therefore no one will ever persuade me, that in these very thin liquids globules of any sort, or shape can be distinguished: *Séve* then I believe is a secondary liquid, and separated from *Suc,* by means of organs equivalent to glandules, but contained in vessels, or receptacles more ample, and very different in structure and use, from the Arteries and Chyle Ducts of the Plant. As in the Human Body there are the sanguineous Vessels, and the Lymphatics, and there are the Cellules of Fat, so many kinds of Plants have their Arterial vessels, and in a certain manner Sanguineous, through which the aqueous nutritive very thin humour spreads in the Plant; but on the other hand they have certain different Vessels, that more properly ought to be called Receptacles, where some particular liquid is assembled and handled, but secondary, and separate from the general mass. The Tithymals, the Apocynums, the Celidonias, the Papavers, many kinds of Cichora-

ceous Plants etc., for example, have vessels properly and generally by their nature Arterial, which carry their nutriment to all parts of the Plant; a portion however of their *Suç,* worked and separated in some glandules, takes the form of a Milk, and is deposited and handled within certain more ample Vessels or Canals, and by them appropriated. This Milk, as I believe, is the *Séve,* and this observed with the Microscope, appears all formed of little globules, as emphasized on page 334 (89), and this alone forced out as it were, and removed, assumes a color dark and blackish. This Milk however is not the nutritive humour of the Plants in which it is found, and it absolutely is not found in Frumentaceous Plants, for the same reason, that Fatness is not found in all Animals. Therefore I cannot concur in the opinion of M. Aymen, that the black color of the powder of the *Carbonchio,* of the *Volpe,* and of the dry Rust of the Straw, depends on the reunion and amassment of many globular bodies, of a nature supposed to serve as nutriment to the different parts of the Plant; nor that the *Séve* forced out from its canals, evaporates the more aqueous part, and its other component substances, remain in a form solid and round. It was seen above that the globules of the *Volpe,* and it will be seen below that also those of the *Carbonchio,* are always black, be they fresh, be they dry, be they young, be they old, as well solitary, as amassed, and it is easy to ascertain that they are organic bodies, not accidental aggroupments. Among his other observations, M. Aymen says [171] he has taken some seeds of Wheat *Volpato,* the internal substance of which was not as yet exactly black, and that having permitted it to dry in the Sun, he found that its substance was not whiter, but appeared formed of little tubes filled with black globules, which were distinguished with the Lens. In the very many Kernels *Volpati* of various ages that I have examined with all possible attention, I have never had a sort in which I found an atom of white color, nor any of these Little Tubes. Not even have I found similar things in the *Carbonchio* of Sicilian Wheat, in which M. Aymen says, that they appeared most sensibly: perhaps our *Volpe* is different from that of the other Countries. M. Aymen then tells, of having made the same tests upon proporine powders of the Persicaria, and upon the red powders which are found on the Leaves of the Buckwheat. *Des que ces poussieres ont eu agi* (that is to say after they had disgregated in water, and sucked it up they became swollen) they decomposed into yellow globules, but he had not been able to discover how many of these yellow bodies would compose a molecule of such powders (and in fact this could not be

[171] A p. 369.

discovered, unless each molecule is a single globule). The globular Bodies of the *Carbonchio,* and of the *Volpe,* he proceeds to say, are so small, and their motion is so quick, that it is not possible to count how many of them they are placed in a droplet of water: notwithstanding it appeared that the black powders are divided into many more globules, than the red powders, and that the black are larger, and composed of a greater number of globular bodies, which would be the proporine powders; and he exerted himself to prove, that the colors of such powders depend on the union of the globules, somewhat as in human Blood. He adds [172] that he has taken the Powders of the *Volpe,* and of the *Carbonchio,* and has placed them in water, and has ascertained that they become yellow, in the measure that the moisture penetrates them; which combines with my observations, because when the little globules of the *Volpe,* and of the *Carbonchio* are distended, and swollen as much ever they can, they become clearer in color through the thinning of their membranes. In so far as concerns the cause of the *Volpe* of the Wheat, M. Aymen says he has observed, that it occurs more commonly on the late ears, that is to say on Wheat seeded late, and forming ears late; and that on Wheats that have been inundated, that have grown in poor soil, been replanted, and not manured, as also in that which is not left in stubble, but is seeded one year to Oats, and the other to Wheat, the *Volpe* is discovered on the Wheat, the *Carbonchio* on the Maize, and the *Ergot* on the Rye. Count Ginanni moreover has observed, that the *Volpe* is frequently rather in the humid Countryside, than in the dry,[173] and inclines to believe, that such Malady consists *in certain less perfect weaving, and natural weakness of the Fibers of some germs of the Seed,* which is confuted by my Observations referred to above. Finally M. Tillet was of the opinion, that the powder of the *Volpe* produces, and multiplies this malady; but Count Ginanni contradicts this supposition, with the support of conclusive observations.[174]

The *Volpe* is a malady of the Wheat, especially of the *Gentile,* unknown to the Ancients, or at least not described by them. Gio. Gruyerino [175] says that in the Mountainous Country of Lionese, the *Volpe,* which he calls *Chambucle,* began to be seen about 1530, and Gio. Batista Van Helmont [176] says *A. 1550 in Augusto Galli primum viderunt Triticum quod vocant Roratum, sive Mellitum, in Arista adhuc viridi Halecem fumatam odore*

[172] A p. 367.
[173] Par. 2. Cap. 7. § 27. Par. 3. c. 3.
[174] Par. 3. c. 7. § 20. Par. 3. c. 3. § 6.
[175] De Re Cibaria L. 5. c. 1. p. 245.
[176] Tumulus Pestis cap. 5.

referens, in matura vero nil nisi pulverem atrum; Popularium utinam non Morborum causam. Count Francesco Ginanni [177] assures that it was recognized in the Territory of Ravenna, and began to be seen there in earliest times; that it spread into Lombardia from Germany, and became universal thereafter about the year 1730; and that in the Territory of Cesante it was unknown before the Year 1738. In my *Chronica Meteorologica della Tuscana,* I find no record of the *Volpe* in notable quantity, except in 1693, after a great abundance of rain, and much cool air in the Spring, and in 1695, and 1698, after a great Winter Cold, and many Spring Rains at the time of Granulation. The distribution of the *Volpe* to some Countries first, to others later, is greater evidence of its vegetable nature, since also the Seeds of the Chokeweeds are every day occupying greater Territory, and advancing always to where they never were seen before, since through ignorance, and obstinacy the Countrymen, and through inattention the Patrons, have never taken advantage of the rules promulgated by Micheli, and have never voluntarily proposed to carry out the necessary extirpation. Certainly this would be more possible by human force, than the extirpation of the Rust, of the *Volpe,* of the *Carbonchio,* and other similar Plants of extreme smallness.

Natale Chomel [178] says, that some French Countrymen, use the following precaution, to prevent the *Volpe* from attacking their Wheat. They take a cord one thumb thick, six or seven canes long, and before the rising of the Sun they pass and repass it over the Ears of the Wheat, holding it taut, and a foot and a half high, which is equal to a little more than our *braccio,* by which agitation there is shaken off, and falls to the ground the humidity of the Fog attached to the Wheat. M. Duhamel du Monceau [179] recounts that some Cultivators of England, having observed that some Wheat wet by misfortune with Sea Water, when seeded produced Wheat not at all damaged by the *Volpe,* which abounded in surrounding Fields seeded with other Wheat, began then to hold the Grain to be sown in infusion in a strong Brine, to save it from the *Volpe,* and they obtained the desired result. He says likewise, that according to the opinion of M. Tull, it is necessary to sprinkle the Wheat a little with a strong Brine, turn it over, and sprinkle it anew; then with a Sieve spread over it pulverized quicklime, and sprinkle again with Brine, and spread upon it again the powder of quicklime several times; thus the Wheat is prepared, and when well dried can be sown immediately. He adds that in many Provinces of France,

[177] Par. 1. Cap. 3. § 2.

[178] Dictionnaire Oeconomique T. 2. p. 77.

[179] Traité de la Culture des Terres ch. 18. p. 229.

they do not employ Salt for this dressing, because it is too dear, but hold the Wheat in infusions of Lime water, rejecting that which remains afloat. Others sprinkle heaped up Wheat with this water, or spread pulverized Lime over it, turning it over many times (as is the custom also in some parts of Tuscany.) M. Duhamel moreover notes, that all these precautions notwithstanding, much *Volpe* is found in the Grains; and that many think a safer method of holding this malady at a distance, is to change the Seed each year, and take it from strong soil. Sig. Francesco Home [180] writes: *The too great abundance of the Saps of the Plants, causes them to sojourn a long time in the Vessels, so that they become corrupted there, and cause enlargements there, rottenness etc. Thus it seems that in this manner the excessive Rains produce damage in Plants. The Volpe should not be forgotten here: it attacks the diseased Grains, both in the time of the Rains, and by being communicated through infection, since in the manner of other contagious maladies, the infected Grains corrupt those that are healthy. I have learned by experiment that this is a fact: Wheat* Volpato *was seeded, mixed with other good Wheat, and all that was harvested, was* Volpato. *It is not amazing, that there happens to the Juices of Plants, what we see happen continuously to the Juices of Animals, which assume the quality of the Contagious Ferment that is communicated to them. This Malady is prevented, at least in great part, by steeping the Wheat in a Brine of Sea Salt. The Brine works in two ways: it strengthens the Sown Seed, and it puts it in condition to suck up aqueous Juice so that it will thrive more than necessary; and secondarily it becomes heavy, sustaining in floating position the empty and wretched seeds, so that none fall to the bottom except the strongest.* Count Ginanni [181] here has brought to light various other remedies, to be practiced to save the Wheat from the *Volpe,* that is to say 1. That of working the Soil profoundly, pounding it, and shaking it, before seeding it. 2. That of fertilizing it with prepared Manures, in which there would be no straw of Wheat *Volpato.* 3. That of holding the Wheat to be seeded in infusions of Lime water, or in Lye from Ashes, or in Brine, or in putrified Urine, or in infusions of Muck, or in well heated Grape husks, or in Oil dregs dissolved in the Lye. 4. That of scattering upon the Wheat to be sown finely pulverized Sulfur. 5. That of picking out and carrying away all the Ears *Volpate* in the Field,

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[180] Principi dell'Agricoltura Par. 5. Sez. 5.

[181] Par. 4. Cap. 3.

before cutting the Wheat. I do not know of how much value this diligence would be, since M. Aymen [182] asserts that, he has tested by seeding Wheat mixed with the powder of the *Volpe,* and of the *Carbonchio,* and also held infused in water infested with these powders, even scattered the same powders in quantity in the Soil, and has seen that not all the Wheat sown became then *volpato,* and *incarbonchito,* which does not even happen after having sown Dregs, punctuated with black. Then M. Aymen adds [183] that the powder of the Wolf Puffball corrupts the Seeds of the Wheat, and causes them in great part to degenerate into *Volpe,* and into *Carbonchio.* To him it appears that the black powder, into which the mature and dry pulp of the Wolf Puffball disintegrates, is precisely the same as that which is found in Kernels of Wheat *Volpati,* and *incarbonchiti,* and he asserts that he has compared them also with the Microscope; I on the other hand, have found them quite different, as noted above at p. 305 (24) and am certain that they will be found so, by anyone who will take the pains to compare them. I suspect then that something equivocal occurred in the experience of M. Aymen, and I cannot persuade myself, that classes of Plants so diverse, as are the Lycoperdons, and the *Volpe,* and the *Carbonchio,* have anything in common, and are one and the same, producing similar effects. He says moreover, that upon making the Sowing after abundant Rains, much *Volpe* occurs, perhaps because the water has an action on the Seed, and penetrates it in too great quantity, causing an internal discord; and he notes that the *Volpe* is more frequent in soil that is not left to Stubble, and in those Fields that have been seeded late; where there is much manure, and it is not well scattered. Therefore he believes [184] that the safest remedies against the *Volpe* are: 1. to hold the seed in infusions of Lime water; 2. to work the Stubbles well and many times; 3. To enrich poor soil with Manure; 4. not to load the soil too much; 5. To sow the Wheat at the proper time.

The leaves of the Maize, or Sicilian Corn, in the Plain of S. Baldassarre on the day July 2 were thickly sprinkled with round spots, like signs of droplets of water, of a diameter of about two lines. The smallest of these spots were of a very vivid red crimson; the mediocre had such a color only at the circumference, but in the middle they showed an area of dry leaf; and the largest of all had in the center of this dry area, a spot black as ink, and there precisely observing them again the morning of August 3 dried a shade, I found almost all of them pierced, by as much as the black spots

[182] Supplement aux Memoires sur les Maladies de Blés. p. 392.

[183] P. 394.

[184] Second Memoire p. 382.

occupied; a sign, I believe, that these points had been gangrened, and burned by some substance deposited thereon, which had caused also other spots of dryness, and of concentric crimson, according to the sphere of its Caustic activity. What then would have been this Caustic substance, whether a kind of Rust, or one of the August dews, or the corrosive Dews, I cannot say, not having had an opportunity of making the necessary observations. I intend to say that in the Plain of Sesto the Sicilian Corn, besides by August dews, and by Plant Lice, had been afflicted by large Worms, that nestle in the axis of the fruiting Ear, and disembowel it, so that they aroused fear of a poor harvest also of this very important Grain, even more than did the terrible Drought, which beginning on the day July 18, and continuing until the day September 9, with only the interruption of a short Rain on the day August 16, deprived the Vegetables of opportune food.

The Sicilian Corn suffered another grave malady in the Year 1766, that is to say the *Carbonchio,* of which I have found the description in the beautiful Work of M. Carlo Bonnet, entitled *Recherches sur l'usage des Fevilles dans les Plantes*. There [185] M. Bonnet says, that an ear of the Sicilian Corn afflicted with smut weighed 36 ounces, and had Kernels monstrously increased, because the smallest were as large as a Hazelnut, and the largest as large as a Chicken Egg, oblong, flattened on the sides, and unequal above, formed on the outside by membranes of the color of silver, thin, and easily bursted; internally then composed of many layers or plates, placed one next to the other, with of the voids filled full of powder of a brown blackish color, stinking, and similar to the powder of the Wheat *volpato*. He adds that from such ears there drains a blackish and stinking water; and that this is the malady called by M. Duhamel *la Bosse* to distinguish it from the *Nielle* (that is to say *Carbonchio*) properly speaking, that completely destroys the Kernel. The first Ear of Sicilian Corn affected with Smut, that was brought to me the day September 10, obtained from a Manor at Murello, was withered, rather small, and stunted, with few Kernels, and with few and short membranaceous involucers, that had never bound all the Ear. The Kernels had all become long purses, not exceeding six lines, with dark, large, wrinkled and somewhat dry membranes, and within they were full of very minute powder of a dark almost black color. In these Kernels when torn, appeared a kind of fine hairs, and ravelings, that were part of the husk, but were not in concentric layers, as are those that show in the figure of M. Bonnet. I noticed also that when the Smut-affected Kernels were torn, and

[185] Mem. 5. § 112. p. 327.

shaken, the powder did not fall quickly, neither easily; on the contrary, I believe, that the very small components of it are attached to the described fine hairs, or raveled expansions. The morning then of September 14, there was brought to me from Quercito a young Ear, and fresh of Sicilian Corn affected with Smut, and others like them I found on the day 19 in my Garden of the Repose of the Aged, in which I noted, that the *Carbonchio* is always in the apex of the Ear, but of the lower Kernels few had become fertilized, and sufficiently nurtured, because the greater part are very small, slender, and empty, the sheath only, or membranous little cupola that surrounds them being increased and enlarged. The Kernels affected with Smut were very large and full, and one of them was as large as a Verdino Fig. Their membrane was smooth, shining, of a very beautiful pearly color, in substance somewhat coarse, but tender; and within was the powder, but mostly in the form of oily and sticky Filth. These Kernels permitted to dry and being re-observed the day October 21, appeared dry, of the color of soil, somewhat shrunken, cracked into many shreds, and torn lengthwise, not concentrically or parallel, and all soiled by the dark powder, which was attached tenaciously. The morning of September 15 I observed with the Microscopes of Sig. Doctor Guadagni the dark powder of the first dry Ear, and I found it not to be other, than innumerable little crystalline globose bodies tending to ovate, but about four times smaller than those of the *Carbonchio* of the Buckwheat, described near by, and with some remainder of a very slender little stem, and mixed among these were seen bits of the veiling membrane. I observed likewise the black slime of the fresh Kernels, and distinguished easily the above mentioned crystalline little bodies with shade of lead, rotund to ovate (Fig. 45), not perfectly smooth on the surface, but with advertisement of very small knots as is customary with some kinds of Rust. Enclosing some, and pressing them between two sheets of Crystal, they appeared cracked, and to have poured out a somewhat oily liquid. On the same Plants, in my Garden, there were other ears not at all affected with Smut, but not fertile, and remaining very small without developing; on others there had grown only the membranous chalices, but the Kernels were empty and aborted, and others had grown moldy, or worm eaten. If the Ears of the Sicilian Corn should become perfect, and conduct to perfection all their Embryos, it truly would be a felicity for us; but commonly many of them remain empty and sterile, and especially in the past year, owing to the contrary weather, fertilization of the Kernels was in great part scarce, because either the Winds, or the Fogs, or the Rains, did not permit that the tubes of the Embryos could receive opportunely the Seminal powder of

Apexes too far distant. The *Carbonchio* of the Maize has been described also by M. Aymen.[186] He notes that the internal substance of the Kernels affected with Smut is black, composed of fine Threads that at first are white, and then become brown, which extend from one extremity to the other, and are covered by a black powder; and that some Kernels are in part affected with Smut, in part healthy. He asserts moreover, that the Tubes of the Female Flowers, situated on the apex of the Kernels of the Maize are vitiated, that is to say tumefied, and shriveled *ou Boursufflees* considerably, coming to equal in size a feather of a Chicken. Hence he is of the opinion that the *Carbonchio* is not other, than a Kernel not fertilized through the defect of the Tube, and becoming like a Millstone. He says [187] that the Countrymen in France cut off at a certain time the Spikes, or panicles of the Masculine Flowers of the Maize, but if they are too late in cutting them, therefore the Feminine Flowers are deprived of that juice, that rises to the panicle through the development of the stems, hence the stigmas not having a sufficient quantity of juice, dry up, many Ears remain sterile, and many become affected with Smut. He says he has tested for two years the cutting off of the Panicle of Flowers, before the time of the appearance of the Stamens, and has left some from place to place, that is to say such a quantity as he believed sufficient to fertilize all the Stalks, which he conceived to be twenty by twenty feet. It happened that all the Stalks of the Maize, where betimes he had cut the Panicle, did not become affected with Smut, as were many among those where this attention was not used. I however would believe that such an observation should be repeated for several years, before relying upon it, because to me it appears a thing against nature to take away half of the Masculine Flowers, so necessary for the fertilization of the Seeds. To me better care appears that, which the same M. Aymen prescribes, that is to say to sow the Maize early, to the end that it will be insured and fortified, at the time when the *Carbonchio* is able to damage it. He adds finally that M. Carlo Bonnet [188] does not appear to be far from believing, that the *Carbonchio* of Sicilian Corn can be produced by Insects, considering that the diseased Kernels, have some similarity to a Gall. M. Aymen [189] has found in the leaves of the sheath, and in the stems of Maize, or Sicilian Corn, certain tumors, at times as large as an Orange. Their substance at first is white, thereafter becoming yellow, and some days later appears formed of

[186] Second Memoire sur les Maladies des Blés. p. 361.

[187] p. 385.

[188] Recherches sur l'usage des Fevilles dans les Plantes Mem. 5. § 102. p. 329.

[189] Second Memoire sur les Maladies des Blés. P. 365.

nothing other than very fine and very black powder. He adds that upon detaching such tumors, it is perceived that beneath them rest many broken vessels of the Plant. I have not as yet been able to see such tumors, and I cannot say whether they are some kind of *Licogala,* or of *Mucilaggine Micheliana,* and never have I found them on the Millet, or *Milium Arundinaceum subrotundo semine luteo, Sorgo nominatum C. B. Pin.* which also, referring to M. Aymen, is subject to such a malady. The tumors on the stems of Maize are described, and figured also by Fil. Iac. Schlotterbee.[190]

The common Millet, or it would be *Milium Arundinacium subrotundo semine,* had been in this year very much damaged by the August Dew, according to the expressions of the Countrymen, as also the *Sainella,* and both have leaves of a texture analogous to that of the Wheat, harder however, and with beautiful rows of aqueous semi-oval Vesicles, but rather small, throughout the vascular partitions, with short hairs. The first August Dew of the Millet, which I saw on the day June 28, consisted in a thick sprinkling, on the Leaves, of spots of a vivid red, like blood, round, of various sizes, that resembled traces of a liquid rained down upon them. Spots of the same color, but larger, and irregular in shape, soiled here and there the sheaths of the leaves, that embrace the Stalks of the Maize, and also the same Stalks, the more they approached the ground, so that they made these fresh Plants with such spots of blood appear unsightly, and the leaves most affected by them very quickly dried up, beginning at the point; but even when dry they retained the red spots, although more faintly. These red spots were called by the Countrymen *Melata,* but on the first occasion I could not distinguish any oiliness, or sweet taste as of Honey, and upon scraping with diligence a spot more vividly red, and placing it under the Microscope, I saw intermixed only a shapeless, mucous and fibrous substance, having many little globules of Rust, made in the form of a Hemisphere surrounded by a little cracknel, like the little globes of the Rust of the eighth kind (see Fig. 20) usually appear, when they are more than usually full of liquid; and perhaps also this depended upon this material being compressed between two glasses. It seems then credible, that even the described red spots of the Millet, are caused not by the August Dew, but by little tufts of Plantlets of the Rust of the eighth kind, or at least in addition to it, which in the Millet, and in the *Sainella,* considering the hardness of the fiber, and the robust texture of the

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[190] Schediasma de Monstris Plantarum in V. 2. Actor Helveticorum Physico-Mathem. &c. Vol. 2. p. 9. Tab. 3.

Canals, cannot with all the branching of the radical Crust, take in a great quantity of food, and vegetating with force, produce the tufts of little stems sustaining the globose fruits.

The true August Dew I found only in the upper parts of the leaves of Millet, brought to me from the Plain of Sextus the morning of July 27, in the form of droplets similar to those of Oil, or of Syrup of Sugar not much thickened, transparent with tints of yellow, sticky, and sweetish in taste, like Manna dissolved in a little water. I kept some of these leaves in my Museum dried out in the shade, and upon reviewing them after eight days, I again found the same droplets but dried up, and shining like a coat of varnish, without having damaged the surface of the leaf beneath them. At other times, I have seen similar drops of August Dew, on the leaves of Oaks, and other Vegetables, and even on the stones that lie beneath, and in the vicinity of these Vegetables, as I shall have occasion to note in its place: whether then it causes the red spots on the Millet, I am not certain, having seen it with very much of the August Dew, and without it also. The red spots very quickly cause the leaves of the Millet to dry out, on which they are scattered, and as in the Year 1766 they were present in prodigious quantity, and unfortunately, precisely on the younger leaves, there appeared in the Plain of Sextus and of Quintus, entire Fields of Millet, with all the top leaves dry, along with the bud of the Ear, and sprinkled with the color of blood, which made them unsightly, but a worse judgment for the poor Countrymen, who lost in herb a great part of the important Harvest of Millet. It should be added that from this unfruitful Millet, they never were able to gain the secondary advantage, of cutting it for straw for the Beasts, because in addition to the described red spots, caused, as I suppose, by the Rust, there is also very much true August Dew, and there was an incredible number of those malicious insects, called by us *Pidocchi* (Lice), and by the French *Pucerons,* which sucking up the August Dew, and with their proboscises sucking the liquid collected in the semiglobose intercutaneous little vesicles of the Plant, multiplied boundlessly, not doing other than to change skin, and bring forth new *Pucerons* beautiful and formed, so that immediately they are placed they will feed, and quite quickly also bring forth a great number of Little Offspring. I have seen Plants of the Millet completely covered with *Pucerons,* and skins of the same, with an infinity of Eggs of other kinds of flying Insects, spattered with much August Dew, spotted thickly with blood color, and with a certain odorous mucosity different from the August Dew, mostly in the cup of the leaves, and in the embryo of the ear.[191] The Compound of

[191] It appears that Conte Ginanni della Malattie del Grano in Erba Par. 3. c. 1.

all these causes, renders this Millet foul and nasty, and because of this it can never be used for food of Cattle, without danger; just as in the Fattoria di Cecina di S. A. R. Heifers are said to have died, after being pastured on similar Millet. I noted at the time when I examined it in a room in my Museum, where I never have seen Flies, I found myself suddenly beseiged by a new flight of them, coming I do not know whence, which avidly went to sucking the drops of the August Dew, and the other fetid mucosity, that stood in the bosom of the leaves. I intended to say that in the Plain of the Campo, the Millets were full of red mites, but also I have not been able to see them.

What little Millet would be of a sort to ear in this year in the Plain of Sextus, and of Quintus, encountered another wild enemy, that is to say the *Carbonchio,* thus named by the Countrymen. This disease causes the Kernels of the Millet to degenerate into very fine black powder, that forms and multiplies within these Kernels, until at the time when the tender ear is held by the last leaf, or Sheath, in appearance healthy and sound, it comes then to tear and rend the cuticle of these Kernels, and it pours outward, and is poured out by some little shake, leaving the skeleton of the Ear, as if scorched by fire. I observed this *Carbonchio* of the Millet with my Microscopes, immediately that it was brought to me very fresh on the morning of July 27, and then at various times, both withered, and dry, with the Microscopes of Sig. Doctor Guadagni, and always I would recognize it to be an ominous kind of parasitic Little Plant, on the order of the *Volpe* of the Wheat, which by its little seeds of imperceptible size scattered by the air, to the top of the sheath leaf of the Ear penetrates into the tender Embryo of the Millet. There then enchasing, or nestling, in a certain manner its short radical fibers, in the canals destined to carry the food to the Embryo, and making them its own, it develops, and forms quickly a thick tuft loaded with numerous fruits, by the amassing of which it swells much, causing the rind of the Kernels of the Millet to crack where it nestles and germinates. In a few words, the *Carbonchio* of Millet seems to me a Little Plant very similar in nature, to that which I described above under the name of *Volpe* of the Wheat, except that the *Volpe* commonly does not rend, or tear the rind of the kernel of the Wheat, perhaps because it is by nature stronger, than that of the Millet, which is rendered probable by seeing, that under the Millstone the Cortex of the Wheat resists much, and becomes divided into large scales, although I have found in the Ear also many kernels of Wheat *Volpato,* cracked, that had been pour-

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§ 3. stresses the union of the August Dew, and the Rust on the same Plant.

ing out black powder. Observed with the Microscope the very fine black powder constituting the *Carbonchio* of the Millet, is seen not to be other than an immense number of very perfectly spherical little balloons, which in a certain light show a black point in the top, (Fig. 46) and in other lights show a little black cracknel surrounding them (Fig. 47). These are smaller by three or four times than the little globules of the *Volpe* of the Wheat, but smooth on the surface as if made of crystal, and transparent as this crystal, except that they have a light tinge of black, as is said of a Diamond of black water. This perfectly globose and smooth shape of the fruit of the *Carbonchio* of Millet, incline me to count it a kind of Rust, that is to say of a class of Microscopic, Parasitic Plant, solely born, and growing within the substance of other Plants. To speak the truth I have not succeeded in discovering any indication of stems, or little stalks, that sustain the little balloons of the *Carbonchio,* but because of this I do not find myself forced to change my idea of its Vegetable nature, both because the analogy of the above described kinds of Rust persuades me, and because I have not been able to find the least indication of Animal product.

M. Aymen [192] has observed also a kind of *Carbonchio,* or *Volpe,* in the seeds of the *Persicaria Urens, seu Hydropiper C. B.* Pin., which by this malady are filled with a certain powder purple, of stinging taste, and has noted that the spikes thus *Volpate,* are ordinarily the latest.

The *Carbonchio* of the Millet is very similar in nature and effects, to certain other maladies of Cereal Plants, described by Botanists under the name *Ustilago,* and by Count Prospero Ginanni under the name *Filiggine del Grano,* called by the Germans *Miltaw,* and *den Brant,* in Lombardy *Carboncino,* and included by our Countrymen under the general name *Carbonchio.* I truly in the year 1766 did not find even a single Ear affected with smut, but in other years I recorded having seen very many of them, especially on Barley, on Oats, and on divers Grasses. Under the name *Ustilago,* this disease has been confused by some Botanists with the *Volpe,* and also with the Rust.[193] Gaspero Bauhino [194] thus describes it. *Ustilago Frugum Cerealium, praesertim spicatarum, et maxime Siliginis, Secales, et Avenae morbus, seu potius pestis est. Ipsis autem accidere solet, antequam e Gramineis vaginis spicae penitus sese explicent, ac in culmum attollant, idque Coeli constitutione crebro incostante: quando enim Aprili et Maio Mensibus, post Solem ardentem subitae*

[192] Second Memoire sur les Maladies des Blés p. 360.

[193] See Ginanni P. 1. Cap. 2. § 2.

[194] Theatri Botanici L. 1. Sect. 4. c. 28.

Pluviae succedunt, et Sol continuo ardentes radios spargit,[195] *spicae adhus tenerae, ac latentes, humore madidae, a Soli, fervore correptae, sic aduruntur, ut quamprimum e vaginis prodeunt, nigrae, et pulvere fusco, aut atro obsitae appareant, quae inarescunt, et ad Frugem non perveniunt: quod malum saepenumero etiam Vitibus florentibus contingit.*[196] More elegantly Mattia Lobelio [197] says: *dum in Floribus atque Granorum spe adhuc est Spica tenera, si compluta madidaque Imbre fuerit, ac repente Sole fervidiore arefacta, iam vitium istud sterile fit: Spica pulverulenta situ fusco aut atro obducta, quae illico quasi defloresceret, in pulverem, ambustamque teredinem cariosam fatiscit.* Also Barley, Spelt, Millet, the *Gramen Avenaceum elatius, iuba longa splendente Raii Syn. p. 260,* the *Gramen Arundinaceum, acerosa gluma nostras Park. Theat. p. 1723,* and the *Bromus Panicula patente, spiculis ovatis Linn. Flor. Svec. 84,* and the one-leaved Aconite, are subject to *Carbonchio.*[198] There are to be added to these, according to the observations of M. Aymen,[199] the *Escurgeon,* the *Gramen Dactylon angustifolium, spicis villosis Inst. R. H.* the *Scorzonera palustris pulveriflora. R. H.* the *Lychnis sylvestris alba simplex C. B.,* the *Persicaria Mentz.;* the *Tragopogon Moris.,* the *Caryophyllus sylvestris vulgaris latifolius C. B.,* the *Alsine altissima nemorum C. B.,* the *Alsine pratensis gramineo folio angustiore Inst.: R. H.,* the *Lychnis sylvestris, quae Saponaria vulgo Inst. R. H.,* the *Muscari arvense latifolium purpurascens Inst. R. H.,* the *Sphondylium vulgare hirsutum C. B.,* the *Phellandrium,* and the Male Flowers of Maize, or Sicilian Corn, except that the Female ears do not suffer, which are fertilized by the powder from the healthy Tops of Plants nearby. M. Aymen has observed with extreme exactness the *Carbonchio* of Barley, which he calls *Nielle,* and says: *Nous entendons par Nielle, ce vice qui reduit en une poussiere noire les fleurs des Blés.* He notes that Ears infected by this Malady when they are in Bud, have sheaths less coarse, and less swollen in the middle, than are the healthy sheaths, and their awns when they

[195] Concerning the weather in which the Carbonchio is discovered see Ginanni Par. 2. C. 6. § 17 e 18.

[196] See Hier. Tragi de Stirpium Historia L. 2. c. 34. p. 665.

[197] Advers. p. 11. Observ. p. 22.

[198] See Lob. Ic. 29. & 36. C. B. Pin. 24. Ginanni delle Malattie del Grano in Erba Par. 2. Cap. 6. § 4. Bonnet sur l'usage des Fevilles dans les Plantes, Mem. 5. § 112. p. 329.

[199] Recherches sur les progres, & la cause de la Nielle, dans le Tom. 3. des Memoirs de Mathematique, & de Physique presentées à l'Academie Roy. des Sciences par divers Savans p. 75. & 398.

burst out of the sheath, are whitish, where the awns of healthy Ears are green. The Ears affected with Smut smell of the Herring, and therefore the Character of *Triticum roratum* of Elmonzio should be adapted also to them.[200] The evil stands in the Kernels, and it spreads out rapidly; first attacked are the Stamens, then the Embryos, then the Chaff, and quickly all of it turns into powder. With plausible reasons M. Aymen proves, that the *Carbonchio* is not an effect of abundant Rains, nor of the August Dew, nor of Insects; neither is it a defect of the Juice of the Plant, and the nature or exposure of the soil is not at fault. He then believes that the immediate cause of this malady, is a condition against nature *du suport,* or of that base, or bracket of the axis of the Ear, where the Embryo could be and was attached, that is to say a local defect of this part, that causes suddenly a tumor, and then a malignant ulcer, which corrodes all the fertilization parts; and moreover he says that it is a defect of the Sweet Sap, which not being able to pass into the Embryo, is corrupted, and becomes Caustic. In another place,[201] he says he has observed, that after seeding Kernels of Mouldy Wheat, their Spikes become affected with Smut, and therefore he inclines to believe, that the Mold is one of the causes of the *Nielle*. He explains then [202] the Microscopical observations made by him on the black powder of the *Carbonchio,* in this manner. *J'ai pris un épi d'Orge Niellé dont j'ai ôté avec le Canif une certaine quantité de poussieres noires, que j'ai mises dans deux gouttes d'eau, contenues dans un ver concave placé sous le Microscope; j'avois auparavant examine scrupuleusement cette eau: les poussieres de la Nielle m'ont paru moins grosses, mais plus rondes que celles des taches de la Paille, leur meuvement est tres prompt. Lorsque ces poussierés ont agi, elles forment une Vegetation particuliere, et tiennent les unes aux autres par de petits Filets, qui font un reseau admirable. On voit des globules faire des efforts pour se detacher de ce reseau; plusieurs même s'en detachent, et nagent en toute direction: a mesure que les globules se separent les uns des autres, ils deviennent jaunes. J'ai fait les mêmes expériences sur les poussieres noires de Charbon du Froment, et du Mais, le mouvement, le réseau de ces poussieres, est le même; elles subissent le même changement, c'est a dire qu'elles deviennent jaunes, lorsque par l'action de l'eau les globules ont été séparés les uns des autres.* I truly have not had opportunity to

[200] See above at c. 342 (100).

[201] P. 83. & second Memoire sur les Maladies des Blés dans le T. 4. des Mem. & c. p. 381.

[202] Second Memoire & c. p. 358.

observe other powders of the *Carbonchio,* than those of Millet, and of Sicilian Corn described above, but something might be wagered, that also the powders of the other *Carbonchi,* are similar in nature and in shape to the two named fruits of very tiny Parasitic Plants. I have contented myself with observing with the Microscope the shape, that so well suffices me for verifying their nature, and describing it, but I have had neither leisure, nor urgency to extend the observations as far as they could go, that is to say up to the development, and manifestation in these infusions of certain little organic bodies, or self-moving particles, or Animalcules as they ought to be called, such as easily and commonly are encountered in the majority of Infusions of Vegetables, and Animals, and such as among others Messrs. Needham, de Buffon, Baker, and Spellanzani indicate, and such as the very kind Sig. Doctor Carlo Alfonso Guadagni has shown me with the Microscope, who has also assured me, that upon holding in infusion for about four days the powder of the *Vescia di Lupo* (Puffball of the Wolf), there will be discovered a very great number of very minute Animalcules. Count Ginanni went to great lengths, to explain the nature, the cause, and the effects of the *Carbonchio* of the Wheat, which he calls *Filiggine* [Soot], and which he says is always observed in the Ravenese Territory,[203] and he has communicated many useful observations and reflections, which I forbear copying, all the more because I have not been able sufficiently, to examine their weight. Solely I shall recall that he [204] says: *The Filigginose ears were ordinarily enveloped in a certain white down, similar to a kind of Mold, scattered upon which were found often drops of water, so that at the top of a Filigginose Ear one Kernel only stood unhurt, although another at this place was clothed in a certain white beard, and filled with black material of the same nature as Filiggine.* I doubt whether this same kind of Mold, or another congeneric tiny Plant, observed by P. D. Antonio Alberghetti, cited by Vallisnieri, and by Count Ginanni,[205] gives reason for thinking that the malady of the Wheat called *Carbonchio,* or *Filiggine,* is of Vegetable origin, that is to say a Little Parasitic Plant, of the Class of the Mosses.

Count Ginanni Par. 4, p. 2, is very concise in indicating the preservatives, and remedies against the *Carbonchio* of the Wheat, and of the other Grains, and only stresses sprinkling the Grains, before they have formed Ears within the proper cases, with fresh Spirit of Sal Amoniac, or with Sal Amoniac dissolved in water, and

[203] See Par. 1. c. 2. Par. 2. c. 6. and Par. 3. c. 2.

[204] P. 82. 86. and 316.

[205] P. 29. n. 49.

mixed with the alkaline liquor of Salt of Tartar, with Sal *Prunella* dissolved in water, and the like. Besides this he advises keeping the Grains isolated, casting the seeds some distance from each other, and extirpating continually the weeds that grow among them, and considering the quality of the Soil, warning not to cultivate it in times of pernicious Winds. M. Aymen proposes [206] some things of the greatest significance. He says that Wheat Molds with great ease, either because of the humidity of the Granary, or because of having been laid apart without being well dried, or because it rained on the Ears in the Shock, or extended in the Field; and he is of the opinion, that such a Mold attached to the Seed, contributes to the generation of the *Carbonchio*. Water of Lime, according to him, protects the Seed from the Mold, which being held in infusion for 24 hours, if it then is dried well, is not then subject to molding. *Whoever wishes to prevent the Carbonchio,* says Sig. Aymen, *ought as quickly as he can, to place in infusion in Water of Lime the Wheat that he desires to preserve for sowing his Ground. For this effect the Rows where the Wheat is more beautiful, should be selected, and saved for Seed; when this Wheat is well matured, it is cut two hours after the rising of the Sun, is carried at once to the Threshing Floor, and beaten the same day, and in the evening the Kernels are placed in the water of Lime, as promptly as may be, are left there during 24 hours, and after those that float have been lifted out, the others are dried well, so as to preserve them in a dry place.* M. Aymen assures us then, that he has practiced this method for several years with great profit. Similarly the celebrated English Botanist John Ray [207] makes known, that the Countrymen of England take care not to sow seeds infected with *Ustilago,* I believe with *Carbonchio,* and for the purpose of holding off such a malady, they put the seeds of the Wheat in infusion for 24 hours, in Leachings of Ashes, and then they scatter over them pulverized quick Lime. Finally it is helpful to note, that Gio. Trago, and Gaspero Bauhino, have noted that Painters make use of the Powder of the *Carbonchio,* or *Ustilagine,* to make a beautiful dark color.

There is another terrible malady of the Frumentaceous Plants, which thrives in certain parts of France, and Germany, but which thus far Divine Mercy has been pleased to keep at a distance from our poor Country. This is the *Grano Cornuto,* or *a Sprone,* or *Ergoté,* as it is called, and it occurs in the Kernels of Wheat, Rye,

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[206] Second Memoire sur les Maladies des Blés p. 381.

[207] Hist. Plant. L. 22. c. 2. p. 1242.

Barley, Tare, the *Gramen Loliaceum,* the *Gramen Myosuros,* the *Gramen Aquaticum fluitans C. B.,* in the Seeds of the *Cipero* of Luisiana, and in the fruits of unfertilized Palms. Kernels attacked by this malady, are longer than healthy Kernels, a little twisted in the fashion of a Horn, of dark color on the outside, blackish within, with many white threads intermixed. M. Aymen [208] describes with greatest exactness the *Ergot* of Rye, called by the Germans *Martins-Rom, Rom-Mutter,* and *Erden-Ropff,* and thinks that it is an equivalent of the *Volpe* of the Wheat, and that the seed of Rye becomes thus monstrous through a defect in fertilization, as he had supposed to befall in the *Volpe.* He assures us that the black powder of the spurred Kernels, observed with the Microscope, appears precisely like that of the *Carbonchio,* that is to say according to his system, it is juice in part extravasated and become black. The described white threads observed with very acute Microscopes by Needham, and de Buffon, and by others, have appeared in the form of Little Earthworms, or Little Eels that move, and they also recover after being wetted many times, and show outwardly a great number of globose little bodies;[209] but M. Aymen thinks, that such little Eels are proper fibers of the Kernel, and that their motion ought to be referred to the motion of the particles of sap contained in the farinose vessels. The Rye Horn, or *a Sprone* [to Spur], has been described with the name also of *Clavi Secalini,* by Gaspero Bauhino,[210] and by Gio. Bauhino his Brother,[211] and by John Ray.[212] Pietro van Muschenbroeck [213] says: *Il tombe souvente en France, quand les années sont trop pluvieuses, une espece de Brovillard gras, que les Labureurs, et les jardiniers nomment Nielle, dont tous les Grains dégénérént. Le Seigle principalement se corrompt à tel point, que l'usage du Pain, dans le quel il entre, devient pernicieux, et cause la Gangrêne. Ce Seigle ainsi altéré, s'appelle* Ergot *en Sologne, et* Blè-Cornu *en Gatinois.*[214] Such Kernels of Rye are spoiled, and are not made use of in the making of Bread, having become extremely harmful to the Human Body, because they offend the nerves, and cause a kind of Intoxication, like the Cockleweed, or else they cause a stupidity, or a great bewilderment, or else Convulsions and horrible

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[208] Second Memoire sur les Maladies des Blés, p. 371.

[209] See de Buffon Histoire Naturelle T. 2. Par. 1. p. 452 and 475. Ginanni Par. 1. Cap. 4. § 3. Par. 2. Cap. 8. § 4 *et seq.*

[210] Theatri Botanici L. 1. sect. 4. c. 17. p. 433.

[211] Hist. Gener. Plantar. L. 18. c. 8. p. 417.

[212] Hist. Plantar. L. 22. sect. 1. cap. 2. p. 1241.

[213] Essai de Physique ch. 39. § 1503.

[214] See Deslandes Traités de Physique p. 99.

pains. Moreover they produce Putrid and Malignant Fevers, and the dry Gangrene.[215] It merits saying here, that Count Ginanni [216] treated at length of the *Grano Ghiottone* [Wheat Glutton], and he believes it one and the same thing as the *Blé Ergoté* of the French. I do not know what I ought to think about this, because the descriptions, and the Figures of Ginanni, do not agree with those of Authors Beyond the Mountains, and it would appear rather that the Glutton Wheat is an abortive Kernel, and for other reasons morbid, but not *Ergoté*. In 1766, in various Ears of Wheat I found Kernels similar to those figured by Ginanni, and called by our Countrymen *Annebbiati* [Deceivers], and in certain others I found empty kernels degenerated into a kind of long and empty Husk, like the *Mater Secalis* described by Thalio,[217] and on the order of the *Secale Luxurians* figured by Gaspero Bauhino. The remedies and preservatives for the Glutton Wheat, can be seen noted by Count Ginanni Par. 4, Cap. 4.

That the Wheats, and the Oats offended by the Rust, the *Volpe,* and the *Carbonchio,* are generally little suited to our Health, cannot be doubted, if one reflects that such Seeds are vitiated by Atrophy, or made ill by ulcers, or changed entirely in substance, in a manner such that they retain little or none of their proper and generic Farinaceous pulp, adapted to be the food of Man. It is true that hard necessity constrains him to use them for filling his belly for lack of better Victuals, but it is likewise true, that after the use for a long time of such vitiated substances, there are often observed to appear on the scene Epidemic Maladies, exterminating entire Populations. I have collected various examples of them in § 85 of my *Ragionimento sopra le Cause, e sopra i Rimedi dell'Insalubrità d'Aria della Valdinievole,* and these I have strengthened with the Authority of many very respectable Masters of Medicine. Here I shall add merely, that Pietro Salio Diverso,[218] treating of the cause of Pestilential Fever, records *omnia Cibaria, quae vitiatam habent naturam, quaeve corruptionem aliquam, vel putredinem sensere, sicuti Frumenta, Legumina, Cerealia omnia Semina, quae Rubiginem passa sunt, et quae quoniam vel diutius, vel male recondita fuere, ideo contraxere*

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[215] See Frider. Hoffmanni Medic. System. Tom. 2 Pathol. Gener. Par. 2. c. 9. § 15. *et seq.* Aymen second Memoire sur les Maladies des Blés p. 377. Mons. Salerne Memoire sur les Maladies que cause la Seigle Ergoté, dans le T. 3. des Memoires de Mathematique & c. presentées a l'Acad. Roy. des Sciences p. 155. Ginanni p. 2. and 7. § 16. n. 96. & 97.

[216] Delle Malattie del Grano in Erba P. 1. Cap. 4. Par. 2. Cap. 8. Par. 3. Cap. 4.

[217] Sylva Hercinia p. 47.

[218] De Febre Pestilenti Cap. 11. p. 61.

labem aliquam. Similarly Giulio Palmario[219] writes: *Si insigniter vitiatum sit Triticum, ex quo communis Panis, aut Cerevisia conficititur, fueritque Aqua, cuius permixtione praeparatur, putris, foetida, ac coenosa, humores in nostris corporibus depravari necesse est, unde infinitorum Morborum Popularium proventus: nonnunquam etiam Pestilentium, venenata pernicie intus genita, quae postea Aerem contaminans, illius contagionem inficiat. Praecipua vero Tritici vitia, haec fere sunt: Syderatio, Rubigo, Corrosio a Teredinibus, Putredo, Marcor, et Tabes. Quum lacteo succo in Spicis turgent Tritici granula, si terrarum exhalatio Roris instar Segetes madefaciat, superveniatque ardentissimi Solis fervor, saepe sit ut lacteus ille humor exustus contabescat, quae plerumque tertiam Aristarum partem exurit calamitas. Spicae hoc vitio infectae, facile internoscuntur ab Agricolis; nam et turgidiores sunt caeteris, et livescunt magis, et digitis compressae in fuliginem abeunt* (he wishes to say they are *Volpate* spikes). *Quod si illae, Messie tempore, cum illaesis reponantur, et conterantur, vitium sanis etiam granis communicant. Hinc Triticum hominibus, et stipulae ac paleae Iumentis noxiae sunt; et quod magis mireris, si hac contagione contaminatum Triticum seratur, vel stipulis in fimetum coniectis Terra aspergatur, illa eo veneno sic polluitur, ut Syderatas Segetes, vitiatumque Triticum ferat. Sic ex insecto Tritico Panis valde insalubris conficitur, quo qui diutius utuntur, nisi vel Furunculis, vel Carbunculis, vel Scabie, aut Pruritu, aut Abscessu, aut frequenti Cathartico expurgentur, brevi in Febres incidunt, easque fere Malignas, et interdum Pestilentes, veneno intus in corpore genito, eo non dissimili, quod aliquando Coelitus in nos demittitur. Qui Valentudinis curam habent, purissimum Triticum si desit, usus tempore sic inquinatum primum exquisite lavant, donec aquam non amplius denigret, dein in Sole siccant, moxque, quia diu conservari nequit, redigunt in Farinam, qua Panis ut candidior, sic multo salubrior efficitur. Pistores Lutetiani Gypsi pollinem Tritico permiscent in sacculos, quem crebra agitatione una cum Fuligine excutiant; sed sic purgatum vitiosum censeri debet, quod siccitatem et adstrictionem alienae materiae redolent, obstrutionesque pariat: praestiterit igitur aut abluere, aut puro uti aliunde petito. Quod immaturum, vel humidum reponitur, aut loco udo asservatur, vel putrescit, vel saltem situm contrahit, ac*

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[219] De Febre Pestilenti Cap. 3.

foetorem redolet, vitiosumque alimentum corporibus praestat. Quod vetustate, aut incuriosa asservatione semiputre, aut etiam foetidum evasit, multo deterius alimentum praebet: vetustate si arefactum est, ac propriae substantiae iacturam fecit, aut Teredinibus exesum, ingenti mole parum, nec tamen probe nutrit. Denique asservatum sicco etiam loco, nisi per intervalla moveas, ventiles, ac pulvere expurges, incalescit, tandemque, calidis praesertim Regionibus, et Aestate, corrumpitur. Also to be seen on this proposition is *Christ. de Helwich de Rubigine sanitati noxia, in Actis Physicomedicis Academiae Naturae Curiosorum, vol. 2. obs. 57.*

In making researches upon the Rust, certain other maladies of Plants were forced onto me, which to me seem of a nature absolutely Vegetable, but not thus easy to understand well, and characterize. Whereas they are intercutaneous, like the Rust, and form a kind of spot, that passes from one part to the other of the leaves of the Plants, also on one surface of the leaves they raise up a little in the rim, or circumference, and towards the center are hollowed somewhat like a shield, in the manner of the Pockmarks of Smallpox. Some of them, mostly the oldest, and those in leaves already dried as a result of this malady, appear entirely dry in the middle, and burned, and even consumed and empty, as on p. 349 I noted to have happened to the red spots on the leaves of the Sicilian Corn. From some of these young spots, fresh, and sappy, scraping diligently with the point of a little blade, I recovered a certain mud, which placed on the Isinglass of the Microscope, and disgregated with a droplet of water, showed me very many smooth little globules, transparent and yellowish, analogous to those of the Rust, mixed with shreds and membranous fringes. From the top however of the spots I have never seen to appear any filamentous, globular expansions, and constantly I have seen always the usual surface of the leaf of the Plant altered in color, but not cracked, except in the middle where I said it was consumed in the more ancient spots. The round holes that appear in the leaves, following the consumption of the parenchyma, would at first sight deceive one, with the idea of gnawing caused by Insects; but one easily is persuaded of the contrary, upon observing on the same leaves the gradation, or ages of the spots, and comprehends that the intercutaneous material by living there, and drying it out, spoils the parenchyma in such a manner, that it is rendered friable, and in behavior like dry powder, which being carried away and dispersed by the motion of the air, leaves the center of the spot punctured. It may be added that I have never been able to discern within any kind of those Insects,

that are called *Talpe,* or *Minatori,* very many of which I saw in the course of the year in the leaves of the white *Cesi,* and I believe are those described by Pliny, and in the leaves of the *Alcea Virginiana Ricini folio Boerh.* Not even could I discern there Eggs or Chrysalids, or bodies of other Insects, and I have not been able to uncover any indication of Animals in the above noted little globules. Turning then from the very accurate, and decisive observations, which others here eagerly made, I now shall record all the variety of such morbid spots, seen by me in the course of the Summer, upon the leaves of diverse Plants, and supposing them of Vegetable origin, I shall include them all under a family of Microscopic Parasitic Intercutaneous Plants, that are born, grow, and fruit within the Parenchyma of the leaves, and fruits of larger Plants.

The first that I saw, were on the Sorrel, or *Lapathum folio acuto plano, ramis surrectis Mich. H. Flor. p. 55, n. 1,* and were certain little spots like sprinkles of water, not all perfectly round, of the color of soil, a little more ample in the superior part, than in the inferior. Material scraped from fresh spots, shows indubitably the globules described a little above, which give the idea of a Plant congeneric with the Rust; some then of the same spots but older, are punctured in the middle, and upon one of these spotted leaves, I found the mines of Insects, which had devoured, and converted into their food the parenchyma only of these leaves, but such a mine is a thing very different from the described spots.

Round, and well circumscribed, of the color of dark blood, were the spots found on the day July 12 on the leaves of the Water Plantain, cultivated in a vase of the Garden of Simples of the Royal Hospital of S. Maria Nuova, called by Tournefort *Ranunculus palustris, Plantaginis folio ampliore.* These passed from one part of the leaves to the other, which were sickly, and yellowish, or so to speak, they had become aged, but on the inferior part these spots appeared in the center as if dry.

Little, but dense, and intrenched in both faces of the leaves of the Catalonian Jessamine, or *Iasminum Hispanicum, flore maiore externe rubente Inst. R. H.,* were the spots which I found on the day August 14, in color filthy red, with the rim raised up, and not well rounded, but angular; the leaves however of the Jessamine, did not give evidence of having suffered great disaster.

Of like shape, but not so small, and darker, and more dense were the spots, which I found on the day July 8, in the Royal Garden of Simples, not only on the leaves, but also on the Meager Husks of the *Siliquastrum Hist. R. H.* Some of these were confined by a line of dryness, and some leaves more heavily spotted, were yellow

and sick, and in these were seen some spots, which in the middle assumed a dried and burned color.

Of the same nature, but larger were the spots on the leaves of a Pear Quince in my Garden for the Repose of the Aged, on the day September 24, and those that I observed on various days of the Summer on the leaves of the Vines, of which I doubt that they can be referred to that class of maladies, which Pliny called *Carbunculatio.*

The *Melissa sylvestris minus odorata Raii Hist. 571* had on the day July 11, in the Royal Garden of Simples, leaves sprinkled with little and irregular, dark Spots, which passed from one part to the other, and had a dark line at the circumference. Among these I found also the mines of Insects, but they were a thing different from the spots. Similar were the spots on the leaves of the *Ballote Matth.,* and the *Marrubium album vulgare Inst. R. H.*

Certain leaves of the *Plumbago quorundam Inst. R. H.* were on the day August 16, in the same Garden, at the tip, and on the circumference sick, yellow, and near to being dried up, and they were sprinkled with round dark red spots.

Many Plum Trees in this Garden, and in my Garden for the Repose of the Aged, at the same time had leaves sprinkled with little round, dark red Spots, which then quickly assumed the color of dryness, that passed from one side to the other of the leaf, which remained unhurt and healthy in its greenness. Reobserving the same spots after a week, I found that many of them in place of spots, had become round holes, all the substance of the spot having turned into powder. On other leaves, along with the spots, appeared vast open mines of Insects, that corroded only the superior surface, leaving the inferior in the form of a transparent veil, graticulated by the nerves united into a network by their frequent anastomosing. Other leaves with spots becoming punctured, were all uniformly yellow because of being dried up, and others conserved among the yellow, certain little round areas of healthy greenness.

A Plant of the double Rose of Damascus, or *Rosa moschata flore pleno Inst. R. H.* cultivated in the Royal Garden of Simples, had on the morning of August 16 leaves sprinkled with round, blackish red spots, that on the superior face of the leaves were elevated in the form of Pockmarks of Small Pox, with a little concentric yellowish space surrounding them, but on the inferior face they were flat, and only suffused with darkness. Reobserving them then in the middle of October, I found many of these spots dry, and transparent in the center, and many others entirely empty and consumed.

The small leaves of the *Helianthemum vulgare, flore luteo*

Inst. R. H., in the same Garden, and on the same day, were sprinkled with little dark red spots, raised at the rim on both faces, and these also reobserved on the morning of October 13, appeared reduced to a veil of dryness in the middle, and in part also punctured.

A Plant of *Fromentone,* or Saracenian Corn, that is to say *Fagopyrum vulgare erectum Inst. R. H.*, cultivated in this Garden, had on the morning of August 16 upon certain sick leaves, and xerampeline in color (that is to say of that color which certain kinds of Grapes assume after the first Frost), some little spots, or little round red blisters, that were elevated a little on both surfaces of the leaves. In the pulp of these little spots scraped, and placed on the isinglass of the Microscope, were seen little globes, on the order of those of the spots on the *Romice,* but much more minute.

There too, the leaves of the *Bistorta maior radice minus intorta Inst. R. H.*, were covered beneath by slight hairs formed like little horns, and among these hairs appeared thickly spots similar to those on the *Romice,* of the color of dark Snuff, which above were reddish, tending towards dryness. Other leaves on the same Plant had certain streaks of dark, and others were as if sunburned, mostly at the tip, and on the edge.

The day July 13 the *Pilosella ripens minor, caule erecto pedali, polyanthes, foliis angustis oblongis Raii Hist. T. 3. 147,* in the Garden of Simples of S. Maria Nuova, had on half of their leaves, and only on the superior face, sundry little dark blood-colored spots, similar to those on the *Romice.*

On the leaves of the *Scrophularia palustris non foetida, seu aquatica minor Inst. R. H.*, cultivated in the Garden of Simples of S. Maria Nuova, I found on the day July 11 many little round spots in color blackish red, similar to those of the Aquatic Plantain, but in the middle of several of them, between the two sheets of Cuticle fastened there, but of the color of dryness, I found the parenchyma of the leaf consumed and annihilated; which caused me to doubt, that it was caused by some Insect miner, of which however I did not recognize any vestige, nor hole through which it could have escaped.

Not dissimilar were the spots I found on the day August 18 on the leaves of the *Sanguine,* that is to say *Cornus Foemina Inst. R. H.*, of which several had assumed in the middle the color of dryness, others were entirely empty, and others showed only the veil of the Cuticle on the inferior part, like the bottom of a mine of some insect. Here there were also from place to place certain sprinklings of white little spots, which observed with the Microscope, appeared to be the beginnings of corruptions in these leaves,

but I do not know well whether because of Insects, or for some other reason.

Of the same nature as the spots of the *Sanguine,* were those, that on the morning of August 16, in the Royal Garden of Simples, I found on the leaves of the ordinary Beet, intermixed however with intercutaneous mines of Insects, different from the spots.

Such, but smaller, were the spots on the leaves of the *Androsaemum maximum frutescens Mich. H. Flor. p. 7, n. 1.,* the *Quinquefolium erectum maximum, flore pallide luteo, petalis cordatis Mich. H. Flor., p. 78, n. 1;* similar, but however minute, were the spots on the leaves of the *Quinquefolium repens Inst. R. H.;* certain ones on the dry leaves of an Oak;[220] certain minute ones on the green leaves of the *Virga aurea vulgaris latifolia Inst. R. H.,* and the *Aquilegia,* and certain larger ones on the leaves of the *Cirsium foliis non hirsutis, floribus compactis Inst. R. H.,* which leaves had also great dry burned areas, and others yellow areas; certain ones finally on the leaves of the Laurel, in which were also the dry burned areas, and other yellow areas with within little green irregular areas.

In the Royal Garden of Simples, on the morning of August 16, I found the leaves of the *Angelica sylvestris minor, sive erratica Inst. R. H.;* those of the *Lapathum folio rotondo, Alpinum eiusd.;* those of the *Echinopus maior, flore candido, staminulis in medio caeruleis, Acanthi folio ampliore Mich. H. Flor. p. 34, n. 2;* and those of the *Tilia foemina folio maiore Inst. R. H.;* those of the *Chamaedrys fruticosa sylvestris, Melissae folio Inst. R. H.,* sprinkled densely with little spots like a scorch of dark color, some of which had a surrounding line of dryness.

On the day June 27 at Malavolta, the leaves of the Artichoke showed on both parts of the leaves, but more on the superior part, certain rather large, dark blackish spots, scattered and dense, as if they were droplets of water, and they did not appear to me the work of Insects. There the gnawings and mines of Insects were however intermixed, in which appeared the dislocated tomentum, or wool of the inferior part, and the gnawed parenchyma, the veiling cuticle of the superior part remaining whole.

Denser and more rounded, were the spots found on the day July 18 in my Garden for the Repose of the Aged, upon the leaves of the *Acanthus aculeatus, pinnis angustioribus, ac venis albicantibus distinctis, floribus albis Mich. H. Flor. p. 2, n. 2.,* that occurred on both the surfaces, of a dry dark color, with a little concentric dry area in the middle.

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[220] See Malpighi de Gallis p. 112.

Vast, and of irregular shape, were the spots of scorched dryness, on the leaves of the Holm Oaks in the Royal Garden of Simples, found on the days July 12 and August 16, and some of them were punctured in the center. These spots are similar to certain others, that were observed on the same Holm Oaks, caused by a Plant usually borne there superficially, which I shall describe below, but in these spots there was no recognized sign of it.

There too, and on the same day, I observed that the leaves of the Vincetoxicum, or *Asclepias albo flore Inst. R. H.,* had only the superior part sprinkled with certain little spots of pallid color, not round, but in a certain manner handsomely adorned, by the usage of a flat Fringe, with some scarcely discernible swellings, which did not appear to me to be the work of Insects. Among these there were some that were round and of dark color, similar to those on the *Romice,* and some of these became visible also on the inferior part of the leaf, with the color of dryness, and on one leaf I found also two vast mines of Insects, which were things quite different from the described spots.

Not less attractive because of the yellow sulfureous color, and denser appeared similar adorned spots, like stars, on parts of the delicate leaves of the *Hedysarum triphyllum Canadense Inst. R. H.,* and of the *Hedysarum triphyllum Americanum, foliis minoribus et rotundioribus Mich. H. Flor. p. 48, n. 4.,* and not even these appeared to me to be the work of Insects.

The leaves of the *Caprifolium Italicum perfoliatum etc. Mich. H. Flor. p. 21, n. 2,* in my Garden for the Repose of the Aged, on the day November 6 were all sprinkled above with little pale spots, adorned like a star: on the inferior part then were seen some defects, and gnawings of Insects, which had nothing to do with the cited spots. May I be permitted to conjecture, that some of these registered spots, are that malady of Plants, which Pliny [221] called Scabies? [222]

I do not know well whether to this section of the cutaneous Parasitic Little Plants, ought to be referred the *Picchiola,* a malady that damages so much the Citrous Fruits in the gardens of Florence,[223] upon which I have not had opportunity to make Observations, and merely I know what practical People say, that it is discovered in the Fogs of Winter, while the Citrous Fruits are covered, since they are all spotted as if with smallpox, and lose much weight from defective nutrition.

The Second Family of Microscopic Parasitic Plants, comprises

[221] Hist. Nat. L. 17. c. 24.

[222] See Ginanni Par. 3. c. 1. § 4. n. 311.

[223] See Micheli dell'Orobanche.

only the cutaneous, that is to say those that enchase the roots within the skin of the leaves of larger Plants, vegetating entirely outside of this, and spreading their branches, and perfecting their fruit. These cutaneous Little Plants are rather few, with respect to the great number of the intercutaneous.

The first is that, which is borne on the inferior parts of the leaves of the Grapes, of which I did not find very much in the course of the Summer, in the Gardens of Florence; and I could not ascertain whether it was this malady of the Grapes, which Pliny calls *Carbunculatio*. Where the tufts of this Little Plant are implanted, the leaves of the Grape are hollowed, and above they make a little hump or projection, but they do not dry up. These tufts are of irregular shape, and the most of them large as a Lentil, and resemble a little piece of Flannel, or woolen cloth well felted, in the beginning white in color, then flesh colored, and finally like Dust and reddish. Some of these Little Plants of various ages examined with the Microscopes of Sig. Doctor Guadagni, were seen to be dense tufts, that at the apex appeared similar to the surface of the Crystalloid Herb. Disgregated then they appeared to have crushed and layered little branches, of a similitude with certain Lichens, and certain Marine Fuci or rather like ribbons woven in a coronet and curled, with the tips a little enlarged, and terminating in a point, and such ribbons are branched, for at intervals at a kind of node, there appear to arise two or three, as it were, divisions (see Fig. 48) or leaves similar to stems, and flattened, and more or less elongate. All these flat and fringed scales, which I called stems or leaves, have their transparency marbled irregularly by little obscure lines, that appear to be not only superficial but also internal. Some of these Filaments were placed and crushed between two sheets of Crystal, without adding water, and it was seen that there issued from them certain things like droplets of Oil. These filaments were placed upon one sheet of Crystal, and allowed to become well filled with water, then they were crushed by superposing on them the other sheet, and then they appeared like so many flat transparent ribbons, with scattered here and there many rows of very tiny transparent bodies, of the shape of an Acorn (Fig. 49) and much like those that on p. 297 (30) I said I found among the Rust of the leaves of the Bean, but a little longer, of which I cannot well say whether they are seeds or another part of the Little Plant, or something united there casually. In the younger and better vegetating Tufts, that is to say those that have not already assumed the color of Dust, which is the sign of aging, there are seen propagating from the described nodes, and also from the radical base certain large bodies (see Fig. 50) not so much flattened, and as if jointed, which

sustain at the top two, I believe, fruits of the shape of smooth Figs, filled with transparent liquid. This sort of Plant was observed also by the Most Oculate Malpighi:[224] In *Vitis foliis,* he says, *non raro tumores eminent, et concavitates variae excitantur, indiscriminatim locatae. Ab inferiori namque folii parte pilorum seu filamentorum congeries erumpit: hi colore vitrum aemulantur, et a lateribus ramosas quasi appendices promunt. Molles sunt et crispi, unde invicem implicantur.*

Much alike in structure are the Little Tufts of the other Cutaneous Parasitic Little Plants, which are borne on the inferior part of the leaves of the Holm Oaks, precisely within the spots of dryness, described above on p. 363 (133). These tufts seem, at first sight, little portions of Velvet of flaxen color. I found them on the day August 16 on the leaves of certain Holm Oaks in the Royal Garden of Simples, and on the morning following with the Microscopes of Sig. Doctor Guadagni, I saw that they were a great number of Tufts of leaflets (Fig. 51) that issue from the leaf of the Holm Oak, the one beside the other, each having four or five leaves, some flat and crushed, others round and pointed. Some of these leaves are prolonged much more than the others, and recurve towards the leaf of the Holm Oak, within which they become hidden, somewhat as does the Cuscuta, called by the Countrymen *Tarpigna* or *Traccapello,* on Flax, and on Genistra, and to me this appears to signify, that from these hidden branchlets as from layers, new tufts would form. In spite of the diligence with which I worked, I did not succeed in finding in this Parasitic Little Plant any sign of fruit, I do not know whether because it was too old, or again too young.

On only the inferior parts of the leaves of a Linden Tree, cultivated in the same Garden, I observed on the same morning of August 16 certain little areas of Downiness, different from the proper hairs of the leaf. These on the following morning, with the Microscopes of Sig. Doctor Guadagni, appeared to be terete hairs like hairs of the head (Fig. 52), which from a radical base enchased in the substance of the leaf of the Linden, prolong themselves more or less, not directly, but for the most part curled, and twisted in the fashion of the Tendrils, or Supports of the Grape, or the branches of Cuscuta, and they end at the point in a sharp Little Horn. They are jointed, or nodose like the Cane, or like certain kinds of *Conserve,* and from these nodes, they send outward two short branches, these again terminating in a Little Horn. The Little Stems between one node and another are transparent, and I believe empty within, because some that at first appeared withered and rumpled, having

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[224] De variis Plantarum tumoribus p. 134. Fig. 79.

placed on them a droplet of water, very quickly beneath our eye revived, and became full and cylindrical: there are among them others little transparent, and rather opaque, which have transparent internodes, whereas the first have them opaque; and I cannot well say whether this is a difference of age, or of sex; and equally the ones and the others, in place of terete secondary branches, send forth certain short and flattened fringes, like the ligules of some kinds of marine Fuci. Among these beards I found certain round little bodies, transparent, for the most part detached, but two or three undoubtedly were attached to certain elbows, or angles of the above mentioned threads or stems, and therefore I suspect that they are fruits, as in the Downiness of the Grape. On the superior face of the leaf of the Linden, there were observed certain little white points, of which I cannot well say whether they are the radical expansions of these threads, or another malady.

The leaves of the *Lysimachia lutea minor* (*foliis latioribus et brevioribus*) *nigris punctis notatis Inst. R. H. Mich. H. Flor. p. 61, n. 4* cultivated in a vase in the Royal Garden of Simples, on the day August 16 appeared dry above, but below sprinkled as with fine powder the color of the soil. This powder, with the Microscopes of Sig. Doctor Guadagni, was seen to consist of capillary threads (Fig. 53), transparent, nodose like the stem of the Cane, but with opaque nodes, branched at right angles, and also acute. Some of the internodes are turgid, and from their nodes go outward certain little bodies, which I believe are fruits, round, and transparent.

On the same day and place, the *Periploca Monspeliaca foliis acutioribus Inst. R. H.,* had both faces of some leaves bronzed in a certain manner, with vestiges of the gnawing of Insects, and with something like fine powder of the color of soil, which although very difficult to scrape, because of its smallness and delicacy, under the Microscope appeared to be branched treads, with round heads, that detached from them.

A similar substance I found on the inferior parts of the leaves of the *Barba Caprae Mich. H. Flor. p. 14, n. 1.,* the *Ulmaria Inst. R. H.,* the *Quinquefolium Inst. R. H.,* the *Caryophyllata aquatica nutante flore Inst. R.H.,* the *Alkakengi Officinarum Inst. R. H.,* and the *Aristolochia Clematitis recta Inst. R. H.*

The leaves of some Plants of the Herb *Trinitas,* or *Ranunculus tridentatus etc. Mich. H. Flor. p. 79, n. 10.* were on the day August 12 blackish above, and very near to being dried up, with spotted areas like very fine ashlike powder. Below then, under the Microscope, they appeared to be spattered here and there with a kind of web of the Spider, thin, composed of round threads, that

implant themselves solitarily on the substance of the leaf, and spread out lying upon it, transparent, with opaque nodes, from which thinly and irregularly they put forth similar branches, and at about right angles, hence these little threads meeting among themselves, come to form a kind of web of the Spider. Similar precisely appeared to me to be the Parasitic Little Plant, which I found on the inferior part of the leaves of the *Thalictrum Mich. H. Flor. p. 49, n. 7.*

Among the many Parasitic Plants discovered by me in the Year 1766 with the Microscope, there were certain ones which are cutaneous, it is true, but not enchased in the substance of the larger Plants, as up to now described: borne therefore as they are on the surfaces of Plants, they branch out then, and extend themselves upon them, attaching their branches by means of radical fibers, as does the Ivy, and like certain Lichens, and also like the Cuscuta. Their food, moreover, I believe they draw only from the humidity of the air, sucking by means of their absorbing cutaneous vessels, since I have proved that scraped, and placed on the Isinglass of the Microscope, the branches appear meagre, empty, and very tiny, but if there is placed on them a droplet of water, very quickly they suck it up, revive, swell up, and appear vigorous and rank growing. This has determined me to record them here all together, under one single Category, or section, or family, which I shall call the third to distinguish it from those preceding: and as these all are of an incredible smallness, on the leaves of larger Plants, where they are usually borne, representing to the naked eye a kind of face powdering or light sprinkling of flour, I believe that the name *Ros Farinaceus* is adapted to them, which various Transmontain Writers have given to a sort of Malady of Plants, as I shall note below.

The first kind I found on the day July 8, spread largely over some leaves, and over various branches of a rank Plant of the Sow Thistle, or *Sonchus laevis laciniatus latifolius Inst. R. H.,* in the fashion of a very fine Ash that had fallen there. This Ash which had the odor of Fungi, observed with the Microscopes of Sig. Doctor Guadagni, appeared like a delicate and fragile web of the Spider, attached here and there to the cuticle of the Sow Thistle, and its threads, all transparent, partly were nodose in the fashion of a chaplet, or necklace of little glass pearls (Fig. 54) not simple but branched, and partly were terete and smooth like hairs. Among these I found many little bodies (Fig. 55) similarly transparent, date-shaped and wrinkled, and even so rumpled, that they appeared angular. Placing then upon them a droplet of water, they quickly revived and swelled up, becoming oval little vescicles, smooth, and transparent as Crystal.

On the day July 12 on certain leaves of *Plantago angustifolia maior Inst. R. H.,* cultivated in a vase at the Garden of Simples of the Royal Hospital of S. Maria Nuova, I found vast areas of material like Ash, and with an odor of Fungi, like the kind preceding, which with the Microscope again appeared to be transparent threads, nodose in the fashion of a diadem, and having intermixed many oval fruits, precisely as in that above. The only difference I noticed here was certain little bodies (Fig. 56) somewhat larger, round like the seeds of the Poppy, not so crystalline, with certain claws, or little hooks attached to them, which within appeared full of other still smaller rotund little bodies. Here I found besides many transparent little bodies, round, very small, of different nature from those noted a little above, distributed in little groups, or bunches like grapes (Fig. 57), and for the most part by threes, which seemed to me attached to certain elbows, or angles of the branched filaments.

An entirely rank-growing Plant of the *Melilotus Italica folliculis rotundis Inst. R. H.* cultivated in the Royal Garden of Simples, appeared on the day August 16 all covered with very fine Ash, and when handled stank of Fungi. This ash, with the Microscope, appeared a weaving only of transparent threads, nodose in the fashion of a chaplet, that had attached to them little bodies, or oval fruits (Fig. 58).

Many Plants of Pulse, that is to say *Ervum verum Inst. R. H.,* sown in this year 1766, on the slopes of My Manor *di Querceto,* were misted over, as the Countrymen say, and grew badly without perfecting seeds. I had some of them brought to me on the morning of June 22, and I found them all covered with the usual ash, which with the microscope appeared to be the usual weft of transparent nodose threads, but different from the three antecedent kinds, because the internodes were not round, but oval, and united at angles (see Fig. 59) somewhat like the leaves of Opuntia, and at the articulation are seen undoubtedly to appear growing out certain oval fruits, rather large, not smooth, but with warty surfaces (Fig. 60).

The inferior part of the leaves of the *Bistorta maior, radice minus intorta Inst. R. H.,* in a Vase at the Royal Garden of Simples, on the day August 16 were spattered as with powder the color of soil, which under the Microscope, revived with water, appeared to be short transparent nodose threads (Fig. 61), that had attached to them rotund, crystalline little globules.

The *Petacciuola,* or *Plantago Mich. Flor. p. 74, n. 5,* on the day August 20 in the Cortile of the Nunnery of S. Maria of the Angels in the *Via Laura,* named for the Angels, had some leaves all strewn as with Ashes, that stank of Fungi. These Ashes under

the Microscope appeared to be a Parasitic Little Plant, borne on the leaves of the Plantain, composed of filaments formed by transparent little bodies, (Fig. 62), date-shaped, and rather oblong, arranged one next to the other, in the fashion of a Taenia, and some of these were so much longer than others, that they resembled truncated Cylinders. Here were intermixed a certain few little stalks nodose in the fashion of a diadem, or necklace of pearls, and here also were globose crystalline very small little bodies, within which three or four cavities were distinguished, and a certain liquid with bubbles of air (Fig. 63).

Various leaves of the Wild Jujube, or *Paliurus Inst. R. H.,* in the Hedges of the Fields outside the Gate of Pintus, were on the day November 6 yellowish, and had on the inferior face certain areas covered as with very fine ashy powder, which to the Microscope appeared a race of Little Plants, similar in nature to those up to now described, with very fine branchlets, to which were attached here and there ovate little bodies, these also transparent, and a little wrinkled. On the superior face of the leaf corresponding to the ashen powder, there appeared certain dark areas of dryness.

To this Family, I believe certain Farinaceous Mildews appertain also, which on the same morning of August 16, and in the same Royal Garden, I found on the leaves of the *Staphylodendron Inst. R. H.,* the Raspberry, or *Rubus Idaeus spinosus Inst. R. H.,* the *Alchimilla vulgaris (praecox) floribus herbaceis Mich. H. Flor. p. 4., n. 1,* the *Chelidonium maius vulgare etc. Mich. H. Flor. p. 25, n. 1,* the ordinary Pease, and the *Jocobaea vulgaris Raphani folio Mich. H. Flor. p. 51, n. 6.* However these Farinaceous incrustations were too fragile, and minute, for me to be able to assure myself without equivocation of their nature.

Of the Farinose Mildew Gio. Ridolfo Cameraria [225] has treated in these terms: *Est quaedam Roris Species, ab Aristotele praetermissa, Pastoribus autem et Agricolis nota, quam Rorem Melleum vocant, Germanice* Honigthavv, *frequens verno tempore, cum arbores florere incipiunt, praecipua arborum, et Pecorum, in primis autem Ovium Pestis. Generatur ex vapore crasso, pingui, oleoso, frigore noctis concreto, adhaerescens floribus, foliis, herbis, et Oleribus, ut quasi Melle perfusa videantur. Exorto autem Sole, ubi Ros ille arescere incaeperit, in pollinem albicantem, qualis Molendinarum parietibus adhaerere cernitur, convertitur: Germanis hinc* Melthavv, *quasi Ros farinaceus* Milthavv *dictus, Gemmae arborum, quae*

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[225] Sylloge Memorabilium Medicinae, & mirabilium Naturae Arcanorum. Centur. 9. § 52.

iam flores protrusurae erant, siccitate contrahuntur, ac in eis pellicula quaedam, in qua Vermiculus inclusus est, qui id quod fructum producturum erat, abrodit, arboresque steriles facit. Animantibus quoque officit, cum herbis insidens, admodum viscosus, nec dum a Sole decoctus fuerit, atque ab illis avidius, quia dulcore tinctus est, imbibatur. Accendit equidem illorum humores, ita ut acredinem, venenatamque qualitatem mora acquirat, fluxiles fereque biliosi fiant, inducuntque symptomata illa cuncta, quae Bilis fervor et ferocia eius deproperant, ut Febrilis aestus, Cholera, ac biliosa deiectio, scabrities linguae, qui affectus Ubergallig *nostris dicitur. Ideo vigilantiorum Pastorum erit, non prius adducere in pascua Gregem, quam Sol Rorem summis Graminibus haerentem, magna ex parte consumpserit.* M. Tillet [226] was of the opinion, that the Rust, the August Dew, and the Farinose Mildew, and those oily materials, that are conceived sometimes on the leaves of Plants of Grasses, Shrubs, and Trees, are always precipitated saps, that are dessicated little by little, and are converted into impalpable powder on certain Vegetables, and that vary in color, according to the kinds of Plants, and the nature of the trees where they are found. My observations referred to above moreover, make clear a different origin for the Farinose Mildew. Liberto Fromond [227] treating of Mildew in general, says that there are certain sorts, because of whose *noxia exhalatio siccato vapore instar Farinae, arborum folia respergit, adurit, et nocet: Mannam Rustici nostri vocant. Lupulum Salictarium maxime haec Lues infestat, et ab hac causa proventus eius incertissimus est, maxime variante pretio.* Would it be possible however to believe, that the *Mossissure,* or Mold that damages the cultivations of Hops in England, is a kind of Farinose Mildew, or parasitic Cutaneous Little Plant? Hales [228] after having understood, how great may be the transpiration necessary to Hop Plants, says that in long rainy and humid periods, without interruption by dry days, the too abundant humidity spreads over the Hops, covering them in a manner, that impedes in great part the necessary transpiration of the leaves, while the sap kept waiting either condenses, or corrupts, and generates the Mold, which often ruins the most beautiful Hop Plants. This befell in 1723, on an occasion of continuous Rains, that endured twelve or fourteen days, and commenced around the fifteenth of July, after four months of dryness. The Cultivators of Hops observed, that when the Mold

[226] See Ginanni P. 3. c. 1. § 8. p. 319.

[227] Meteorologicorum L. 5. c. 4. Art. 2.

[228] Statique des Vegetaux Ch. 1. Exp. 9. p. 28. Exp. 19. p. 61.

is once in possession of a part of the district, it always gains territory and extends through all, in the same manner that also Wild Grasses, and other Herbs, that stand under the Hops, infest them. This probably happens, as Hales reflects, because the little seeds of this Mold, which grow quickly, and promptly age to maturity, are blown and carried over all the extension of the Hop Planting, where they multiply, and sometimes infest the territory for many years afterwards, that is to say each year more, by the germination of the seeds of the Mold of the preceding year. Would it not be better, in such case, to burn the trash of the Hops immediately after the fruit has been gathered; in the hope of destroying in great part the seeds of this Mold? *La Nielle tombe ordinairement vers le 11 de Juin, et vers la mi-Julliet; elle rend les feuilles noires, et les fait sentir mauvais.* We should have examined the Observations of M. Austin of Canterbury, upon the Mold, and the Rust of the Hops, reported by the same Hales, and by the analogy of them, would better have persuaded everyone of the Vegetable nature of the Rust, the *Volpe,* the *Carbonchio,* and the other Maladies of Plants thus far described by me.

I could not ascertain whether among the Farinose Mildews there ought to be registered a Malady of the Mulberries, which has been thus described by Sig. Abbot Giovanni Lapi, Public Professor of Botany in the Royal Hospital of S. Maria Nuova. *At times there is observed, on the trunks especially of young Mulberries, something like a yellow Rust, that apparently cannot be other, than a Microscopic Lichen, which takes sap from it, and causes it to get emaciated, occurring always on mulberries stunted, reduced as if naturally. It is of great importance in the Spring, on wet mornings, to mop up this infection by means of a rough cloth, wiping the trunk. The poor young Plants appear little by little to languish, whether or not this Rust can be the true cause of their languor. Only the intelligent and naturalistic Husbandman, who observes and examines, and experimenting with the desire to know the reason, can deduce that this Rust or Plant, is the true cause of the stunting of the young Mulberries, since in the year after this diligence they appear restored in vigor and fruitfulness.*

The August Dew can often cause great damage to Plants of the Kidney Bean, especially in the Valdarno above, but I cannot well say what precisely it is, unless by chance it is that described above among the Rusts. In the Environs of Florence, the Countrymen call *Melata* certain Maladies of the cultivated Plants, in which I cannot discover indications of a substance glutinous, and sweet

like Honey, deposited upon them. At Malavolta on the day June 27, I saw Plants of the Roman Kidney Bean offended by the *Melata,* at least as the Countrymen would say: They had leaves spotted here and there with yellow, and with brown near to being withered, which upon being sprinkled, in short time extended in all directions, and there was found among them, something like Erysipelas causes, and Gangrene on the Human Skin. Similar spots had been observed by me on the leaves of Melons, many of which extended in the fashion of Herpes on our skin, and they leave the leaf as if scorched, when quickly it becomes empty of sap, and dries entirely. A similar malady I saw on the day August 16 on the leaves of the *Bryonia aspera, sive alba, baccis rubris Inst. R. H.,* cultivated in the Royal Garden of Simples, on which I observed with the Microscope, that the hairs, or little thorns of the inferior part of the leaf, white, have a round base, and are elevated on the plain of the same leaf, with a margin jutting out in the guise of a cornice, all globular, as if they were stones on the circumference of a Ring. From the middle to this base there rises a Cone, or empty Little Horn, smooth, transparent in white, in substance quite delicate, which terminates in an empty hair, long, and curved, that is easily detached, because it is connected by a kind of articulation to the conical trunk. The little thorns of the superior face of the leaves of the Brionia are rather rare, with larger bases, and shorter cones. The leaves of Melons are also all sown with similar conical little bodies, but denser, smaller, and of a color that verges on yellowish. I have understood from persons practiced in Gardening, that the *Melata* of Summer spots with red, and with withering yellow, the leaves of Citrous Fruits, and often causes them to fall, but does not harm Apples. And who knows that to this class of malady, does not appertain that, observed by Doctor Sig. Gio. Francesco Seguier, on the leaves of Pears?[229]

What is said to be a kind of dense Mildew, oily, and as sweet in taste as Honey, has been observed by divers persons, and appeared to be seen by me once, as I noted on p. 24 of T. 5 of the *Relazioni de miei Viaggi.* Moreover on p. 145 of T. 4 I noted, that the Chestnuts of Versilia, suffer great injury from the August Dew, and alluded to other notices of this sort of Mildew on p. 379, and 421, or T. 6, and little above on p. 352 described the August Dew, that on the day July 27, I observed on the leaves of Millet. The Ancients had recognized the Aerial Honey, and also that which is transpired from certain Plants. Theophrastus[230] says: *Quercus*

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[229] See Ginanni p. 249. num. 318.

[230] Hist. Plant. Lib. 3. c. 9.

feras est plurimarum rerum. Si autem, authore Hesiodo, Mella quoque Apesque ferat, magis illud confirmatur. Ergo nascitur hic liquor ex aere, nec aliis magis infidet frondibus; and in the Fragment of the Book *de Apibus* [231] discoursing of the kinds of Honey, he says: *Alterum quod ex aere venit, cum humor ille quem terra exbalavit, a Sole concoctus et refusus deciderit, quod praecipue contingit Messis tempore.* Virgil to this proposal [232] sings:

Et durae Quercus sudabunt roscida Mella;

and Ovid [233]

Flavaque de viridi stillabant Ilice Mella.

Pliny then thus describes the August Dew, according to what was believed in his time,[234] treating of the Honey: *Venit hoc ex Aere, et maxime Syderum exortu, praecipueque ipso Syrio explendescente sit, nec omnino prius Vergiliarum exortu, sublucanis temporibus. Itaque cum prima Aurora folia arborum Melle roscida inveniuntur, ac si qui matutino sub diu fuere, unctas liquore vestes, capillumque concretum sentiunt.* A similar fact becomes contested at length by Galeno [235] with the speech: *Memini aliquando in aestate super arborum fruticum, berbarumque folia, Mellis quamplurimum repertum fuisse, ut ludentes Rustici dicerent, Iuppiter Melle pluit. Precesserat autem nox, ut per Aestatem, satis frigida, nam tum anni aestivum tempus erat, pridieque calida et sicca fuerat aeris constitutio. Quamobrem peritis Naturae Interpretibus, halitus e terra atque aquis prodeuntes, Solis calore exacte attenuati ac cocti, a frigore secutae noctis in unum coacti et densati videbantur: sed apud nos raro id accidit, in Monte autem Libano quotamnis persaepe, adeo ut expansis super terram velleribus, Mel a concussis arboribus decidens excipientes, Ollas, ac fictilia plena referant, vocantque id Roscidum Mel, aut Aerium.* Also Mesue advises about such a sort of August Dew; but about the Aerial Honey of Mount Lebanon, and of the Arabs, there appears what is noted by Pietro Pena, and Mattia de Lobel,[236] and Stef. Franc. Geoffroy.[237] Francis Bacon of *Verulam* [238] writes: *Certum est Mel Roscidum in-*

[231] Apud Photium in Biblioth.
[232] Ecl. 3.
[233] Metamorph. L. 1.
[234] Hist. Nat. L. 34. c. 12.
[235] De Aliment. facult. L. 3.
[236] Nova Stirpium Adversaria p. 25.
[237] Tract. de Mat. Med. T. 2. p. 583.
[238] Sylvae Sylvarum Cent. 5. § 496.

veniri frequentius in frondibus Quercus, quam Fraxini, aut Fagi, similisque Arboris. John Ray [239] treating of the Oak, adds: *Huius foliis, prae reliquis omnibus, conservatum debemus Rorem Caelestem, ex quo Apes Mella conficiunt.*[240] *Aliquando idem praestant Acer minus et Corylus, sed parce.*[241] In the Collection Academique T. 6, p. 590 I find noted: *A. 1696 il tomba l'Hyver, et le Printemps dans les Provinces de Munster, et de Leinster en Irlande, une espece de Rosee, ressemblant à du Beurre.* More extensively Gio. Giorgio Hoyero [242] treats the *Melata* in the following manner. *Melleus Ros a materia subdulci et glutinosa, Arborum ac Fruticum frondibus, immo Frumentis ipsis adhaerente, sic dictus est. Huius generis Rorem annis praeteritis observare licuit in his terris: Videlicet die quarto mensis Julii A. 1669, humor quidam saporis subdulcis, et glutinosae naturae in Frumentis, et Fruticum herbarumque frondibus visebatur. Mellea haec humiditas, sive Ros, grati quidem dulcisque saporis erat, sed acrimoniam volatilem multam quasi subvelantis. Curiosi quippe qui primoribus labris degustaverunt hunc Rorem, singularem nauseam, et vomendi conatum ab eo sentiebant. Nonnullis ulcuscula labiorum suscitaverat. Pauci qui diutius eo temporis momento in Campis commorati fuerant, Febribus Ardentibus corripiebantur: immo qui nudis pedibus incesserant, ut Ruricolae solent, pustulis et ulcusculis pedum nigricantibus inde vexabantur. Ipsa vero Frumenta, quaedam praeprimis Siliginis grana, quibus Roralis eiusmondi Lympha longius inhaeserat, mirum in modum notabantur corrupta, nigricantia ac mostrosa, qualia vulgus Mutter Korn appellat. Quamvis autem fertilioribus annis eiusmodi grana subinde non tentur, adeo tamen anno dicto frequentia plurimis in agris, praesertim in vallibus, et profundioribus locis sitis per universam pene Thuringiam, in primis in Agro et territorio Erffurtensi visebantur, ut post hominum memoriam frequentiora nusquam visa sint. Ab horum usu, loco cibi ordiarii, Anno subsequenti 1700, vix evitabili, variis morbis Epidemicis Iuniores aeque quam robustae aetatis homines affligebantur. Similis consistentiae et saporis Rorem, Anno proxime finito 1701, notavimus, qui tamen cum vernali tempore contingeret, non aeque Frumentis,*

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[239] Catal. Plantarum circa Cantabrigiam nascentium p. 129.

[240] Butler Tract. de Apibus Cap. 6. n. 40. & Theophrast. lib. de Melle.

[241] Butler *ibid.*

[242] de Rore Melleo vitioso, in Ephemerid. Acad. Nat. Curios. Dec. 3. A. 9. a 1701. ed. 1705. Obs. 9. 3 p. 171.

quam Pomis, et Oleribus summe noxius erat, utpote qui verminosa putredine, seu seminio potius scatebat, quod maxime dictorum fructuum parti affricabat. Hinc aliquandiu post Erucae, e Vermibus illis natae, Oleracea plurima depascebant: Poma vero a Rore verminoso laesa, vel decidebant immatura, vel maturescebant verminosa vel sapore amaricante et ingrato maxime nauseosa fiebant.[243]

Notwithstanding however all this authority, there are most respectable Philosophers, who believe that the August Dew is not material fallen down again, and deposited from the air on Plants, but that it is a forced transpiration of the humours of the same Plants. Among these Marco Mappo [244] says: *Tiliarum interdum succus quidam transudat, et folia quasi vernice obducit: est species Mannae, quae etiam in Quercu, et Fraxino observatur quotannis.* Stefano Francesco Geoffroy [245] notes: *ingenue fateor me hunc Rorem Melleum non novisse. Nullus, ut mea fert opinio, succus Melleus in floribus, foliis, aut lapidibus deprachenditur e coelo delapsus. Qui in floribus quamplurimis reconditur, ex Plantae interioribus organis originem ducit. Qui in frondibus, vel liquidus, vel concretus nonnumquam percipitur, vel per foliorum porulos exsudavit, vel etiam ex aliarum arborum frondibus distillavit. Tandem si lapides Mellei humoris guttulis conspersi nonnumquam appareant, non e coelo, sed ex arborum propinquarum foliis distillavit, aut aliquo alio modo ibi delatus fuit. Sie Jo. Bodaeus a Stapel* [246] *refert observationem de Manna optima, albissima copiosa, Saccari dulcedine, in Salicibus, lapidibus, terra reperta, quam quidem Culices erassi innumeri ibi tanta copia deponebant, ut Rorem esse dixisses, si copiam guttarum cadentium ex loco Salicis ubi congestae erant considerasses. Humor ille guttatim depositus in folia, et lapides, brevi concrescebat in purissimam Mannam, albedine, dulcedine, consistentia probatam, et a multis ad usus colligebatur. Verisimile est hos Culices hoc Succo Melleo, vel in ipsis Salicibus producto, vel ex aliis Plantis collecto se se inguritasse, ita ut illum qualem acceperant, varia in loca deponere cogerentur, et eo quidem magis, quod in his Culicibus quaedam corporis*

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[243] See Ginanni Par. 1. c. 1. §3. n. 25. Par. 2. c. 9. § 6. n. 125. Par. 3. c. 1. § 5. n. 313. § 11. n. 321.

[244] Historia Plantarum Alfaticarum p. 304.

[245] Tractatus de Materia Medica Pars. 2. Sect. 1. Cap. 7. de Succis. Gummosis Art. 3. p. 586.

[246] In Adnot. ad Theophr. Hist. Plant. L. 2. c. 9. p. 151.

partes prominentes observabantur, cum parvis foraminibus, per quae guttae quaedam parvae, albissimae, sudoris modo, copiose eliciebantur. Also Lodovico Ripa [247] says: *Humor dulcis et Melleus, quo folia Quercuum saepe madent, et quem Apes studiose eisugunt, non, ut putatur, depluit e Coelo, sed succus quidam redundans est, per plantas illas diffusus.* Thus the great Boerhaave [248] treating of the leaves of the Plants, notes: *Humores illis propri foliis sunt, Mellibus noctibus aestivis foliorum superficiei adlitus liquor, exsudans Cera, Manna, Thereniabin, qui aestu folis agitati, excocti, superveniente frigore noctis densati, colligi queunt.* With greater eagerness the Celebrated Pietro Van Muschenbroek,[249] has examined this point of Physics, and made it clear how, after a very hot day, not merely the fine and watery particles of Plants are found in great motion, but moreover the densest and most oleaginous particles, being thrust even as far as the excretory vessels of the leaves, without being able to turn backwards, cannot evaporate in the air, and are as a consequence obliged to come to rest on the surface of the leaves, where they form a dense material like Honey. He adduces as proof the observations of Donato Altomare, who desiring to investigate the origin of the Manna, which is found in Calabria on the leaves of Ash Trees, and Olives, caused these trees to be covered with cloths, to the end that the Dew of the air would not fall upon them: and notwithstanding this he found the Manna under these cloths: signifying that the Manna did not fall from the air but is a transpiration from those Trees, that more resembles Gum, than Dew. The Dew, says Sig. Musschenbroeck, *is sometimes Oleaginous, as Scheuchzero has observed in Switzerland, and also as I have observed in Summer at Leyden, and at Utrecht, and in their environs, when it was very hot, in the places where there was a great quantity of Trees. There issues from the leaves of these Trees a certain Oil, becoming volatile from the great heat of the Sun, but falling down again quite quickly onto the* Perons bleus, *which become all soiled, or if indeed it had fallen on water, upon which it floats, forming a kind of greasy surface. This is a thing very common in Holland* (where the summer days are much longer than ours in Tuscany) *and there is no person there, who has not been able to observe this Phenomenon; but nothing similar is ever seen in dry and uncultivated places, where*

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[247] Historiae Universalis Plantarum scribendae propositum p. 171.

[248] Chemiae T. 1. Pars 2. de Artis theoria p. 29.

[249] Essai de Physique Ch. 29. § 1533.

Trees ever grow. Thus Kolbe [250] *notes, that the August Dew was never seen on the Cape of Good Hope, before the year 1708, but that after that time it was seen there, because the Country had been uncultivated, without Trees, although now many are seen there, which the Hollanders have planted in the Gardens and Fields, which they cultivate with eagerness. We shall say then that the August Dew takes its origin from trees, and from Plants.*[251] This same proposal, that the August Dew is not deposited from the Air onto Plants, but is a transpiration of the Oleaginous liquid of the Plants themselves, forced by the vehement heat of the day antecedent, is confirmed by an able Swedish Philosopher, who has made certain Critical annotations on the observations of E. A. A. *de Rore deciduo,* in the *Atti dell'Academia Reale delle Scienze d' Upsala dell'anno 1745.*[252] His convincing reason is this: *Humorem ex aere delabentem, quasdam tantum arbores tangere, et calore Solis inspissari, ego quidem non intelligo, immo potius in vapores denuo resolvendum esse duco; quae omnia succi ex foliis emanati indicia potiora sunt. Accidit Opinioni calor ille fortior, de quo verba facit Auctor; nec Auster, nec Subsolanus interest. Dulcedo ex arbore potius, quam e vaporibus delapsis procedere videtur; et succum exsudantem et inspissatum, Arbori noxae cedere posse facile intelligo. Hinc circumstantiae omnes Rorem exsudasse, potius, quam decidisse, loquerentur.* The up to now adopted theory, can furnish great light, in explaining the origin of many maladies of Plants observed by me in the course of the year, and already registered, or to be registered in the remainder of this fifth Part, of which it is not certain that they have arisen from Parasitic Plants, or are ruin caused by Animals. As then to the effects of the August Dew, Gio. Cristof. Fromanno [253] notes: *Ros ille Mellitus, cruda plurima in se continet, et vaporem incoctum, qui proinde adhaerens Oleribus, Plantis, arborum foliis, et Gramini, ea facile corrumpit, abitque in virus, quod quidem dulcedine Pecoribus imponit.* Also, Musschenbroeck [254] writes: *it is said that the Oleaginous Dew is very unhealthy, above all to Cattle, and it has been observed that the year is very sterile, when much of this Dew falls. It is claimed that therefore the Nuts in the Dauphiny*

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[250] Description du Cap de Bonne Esperance.

[251] See also § 1538, p. 779.

[252] See Analecta Transalpina T. 1. p. 393.

[253] De Verminoso in Ovibus & Invencis reperto Hepate, in Ephemer. Acad. Naz. Curio. A. 1670. Obs. 188. p. 252.

[254] Essai de Physique Ch. 39. § 1538.

go bad, and that the leaves of other Plants are burned, as also the Wheat, and the Grape. I do not believe now that this malignity ought to be attributed to the Dew, but rather to the too great heat of the Sun, which takes away from the leaves of the Trees, and other Plants the subtile Oil which they contain, leaving nothing except that yellow Oil, which is the coarsest, and densest, and which the Chemists likewise find to be of yellow color, in a manner such that the most delicate vessels of the leaves break because of the too great motion of the sap, and the excretory vessels open too much, which can cause the Oil to issue and be dissipated.

The Baron of Verulam is the only one, who has given thought to some preservative against the August Dew. *Morbi,* he says,[255] *et Frumento nocua malignitas, inquisitionem merentur; foretque eo accuratius pervestiganda, si in homine esset, depraehaensis malis opponere excogitatam medelam: nunc multa remediis inexpugnata non cedunt. Ros Melleus, vel Melligo, ex iis quae maxime infestant est, ortus proculdubio ex, arctiori aeris compressione, ut raro Collibus, terrisque patentioribus se infundat, qualis apud nos tractus Eboracensis campestris. Hoc malum tolli nequit, nisi inclusa angustiis terra, in laxiores Campos extendatur.* He likewise advises making wider the setting of fruits in rows, thus not encumbering the ground so much, and permitting a salubrious ventilation of the Fields, which merits being observed in our very fertile Plain of Ripoli.

Worthy of consideration is one fact, which I have seen thus noted in T. 6 of the *Collection Academique p. 663. A. 1695, Octobre et Novembre, dans la Comté de Limerik, il est tombé avec la Pluie une matiere d'un jaune foncé, semblable par la consistance à du Beurre, ou a de graisse, qui se fondait lorsqu'on la manioit avec les doigts, mais qui séchoit, et se durcissoit au feu. Elle exhaloit une mauvaise odeur, comme de cimitere. Lorsqu'on n'y touchoit point, elle restait sur le terre environ quinze jours, sans changer de couleur, apres quoi elle devenoit noire en se séchant. Le Betail paissoit a l'ordinaire, et sans inconvènient dans les lieux ou il y avoit des tas de ce' matiere; il n'en tomboit guere deux fois dans le même endroit; elle tomboit par floccon de la grosseur du doigt. Il y avoit eu dans ce même canton beaucoup de Brovillards, d'une puanteur singuliere.* I do not know what to think of this extraordinary Phenomenon; It is however certain,

[255] Sylva Sylvarum cent. 7. § 669.

that he blames always the Fogs full of saline exhalations, sulfurous, caustic, which are harmful to the health of Humans, and Animals, no less than to the vegetation and fructification of Plants. This proposal is to be seen in *Io. Georgii Hoyeri de Nebula singulari Febris Malignae Lethalis causa, in Esphemeridibus Academiae Naturae Curiosarum Dec. 3, A. 9., et 10 Obs. 94, p. 174,* and Count Francesco Ginanni in the *Trattato delle Malattie del Grano in Erbe, Par. 2, c. 5. § 20 e 23. e sur les Nielles brulantes* is to be seen Sig. Hales *Statique des Vegeteaux Ch. 1, Esp. 9., p. 30. Esp. 19. p. 62. Ginanni ibid. Par. 3. Cap. 1. § 10. n. 320.*

To the *Uredine* of the Ancients, that is to say peeling, or sunburn, I doubt if certain Maladies of Plants ought to be referred, which I happened to observe in the Summer of the Year 1766, in making researches on the Rust.

Primarily then, in the Royal Garden of Simples, on the day August 16, on certain Plants of Enula Campana, or *Aster omnium maximus, Helenium dictus Inst. R. H.,* I found several leaves, that had certain long and large stripes of dryness, others contorted and brown, and others yellow and near to being dried up, but with bits of healthy green. Such too, but smaller, had the leaves of the *Aster Chenopodii folio, flore ingenti specioso H. Eltbam.,* which were also striped with tan below and above. The *Lunaria maior perennis, siliqua rotundiore Inst. R. H.* had some leaves, that were sprinkled above with yellow near to the degree of dryness, but in the fuller parts of the swellings that rest between the anastomoses of the nerves, they were all scorched, and rendered white, as if they were very old. The *Convolvulus maior flore albo,* had leaves all spattered with areas of dryness. The *Melissa humilis latifolia, maximo flore purpurascente Inst. R. H.,* and the *Pimpinella Sanguisorba maior Inst. R. H.,* had leaves radiant with the color of dark wine, mostly in the inferior part, and towards the circumference, and there also they were scorched to dryness; the Strawberries had leaves of the same color below with some areas of dryness. The Lime trees of the Grove of the Royal Palace of the Cross, exposed to a cooking mid-day, under the Arch of the Corridor, had on the day June 30 many leaves either wholly, or in part yellow, as if almost dried out, which the gardener said depended on the August Dew, of which I could not distinguish any indication. About this *Uredine* of the Ancients, and the effects of the *Colpi di Sole,* see *Theophrasti Hist. Plantar. cum Adnot Io. Bodaei a Stapel. L. 8. c. 10 p. 959. Cl. Salmasii Exercit. Plinianae in Solinum p. 434. Franc. Ginanni delle Malattie del Grano in Erba Par. 1. c. 1. § 3. p. 12. nota 23, p. 14. nota 24. e Tissot Avis au Peuple sur sa Santé p. 180.*

Whoever delights in making observations on Microscopic Insects ruinous to Plants, in the Spring and in the Summer of 1766, would have been able to appease his curiosity, for the season went forward so favorably for these little beasts, that they multiplied prodigiously, every class of them. In making the observations on the Rust, I encountered quite fantastic races of Insects, but I had not time to be able to observe and describe them well. Only during the extent of October those leaves, and to reexamine all the display of sick Plants, I found that the *Orobus latifolius parvo flore purpureo Inst. R. H.* in the Royal Garden of Simples, had on the day July 11 the leaves on both the surfaces marbled a red filthy color, which to me appeared rather the work of Insects than the effect of the August Dew or anything else. In the same Garden, on the day July 8, the dwarf Apples had many leaves languid above, and losing color, and below among the hairs, and beside the nerves, spotted with a color similar to that of the Rust of the Wheat, but it was certainly not Rust, and black spots were also intermixed there, which without doubt were depositions of Insects. The leaves of the Garland Laurel in this Garden, had many dark spots above, similar to those of the *Romice,* described on p. 360, and dry places bordered with black; below then they were all marbled with black by Insects. On the Chick Pease brought to me on the day June 28 from the Oak Forest for being rusty, I did not find anything other than an immense number of very small intercutaneous mines, that certain hardly visible Little Worms had excavated, by gnawing the parenchyma of the leaves. Finally among the innumerable Lice or *Pucerons,* which were on the Millet, I found very many both large and small, that actually were stripping, and were making their final metamorphosis.

There occur at other times, and in other Countries, Constitutions of the Air similar to that which we suffer in our Spring, that is to say with predominance of the humidity of Rains, and Fogs, with warmth and with intervals of hot air, which assist very much the development, the birth and propagation of Insects. As in such years abounding in Rains and Dews, there are seen to appear immense quantities of little Insects, it has been believed that these are born of the Rains and Dews, and hence there was born among Meteorologists the consideration of the *Verminous Rains and Dews,* about which can be seen *Io. Crist. Fromanni de Verminoso in Ovibus et Iuvencis reperto Hepate, in Ephemerid. Acad. Nat. Cur. A. 1670. Obs. 188. p. 252. F. Fortunati de Felici Adnot. in Io. Arbuthnot Specimen Effectuum Aeris in Corpore Homano p. 23. Franc. Ginanni delle Malattie del Grano in Erba Par. 2. c. 5. § 4. p. 67. Nota 75. Par. 3. c. 1.*

§ 4. p. 288. Nota 311., ed il Sig. Abbate Lazzero Spellanzani, Saggio di Osservazioni Microscopiche, concernenti il sistema della Generazione de' Sigg. Needham, e de Buffon Cap. 10, p. 79.

M. Aymen [256] there brings out other Causes of sterility in Plants, namely: 1. a lack, or some defect of structure in the germ, and in the Stamens; 2. the too great enlargement of the Stamens, and their strangling by a burst of Sun after a Rain; 3. the sunburning, or impeded development of the Apexes, and impeded volatility, and energy of the Seminal Powder, etc.

How many enemies, both great and small, and general and particular, conspire to the injury of our Countryside, and defraud the hopes of the Husbandmen! There will be many more besides, but I find myself already weary of such minute research, which I fear will prove only too noisome to the Readers: a thing undertaken, and as a short Digression, but little by little *Magna de Nihilo nascitur Historia*. It would be better then to end at once, and at least to conclude, that the Classes and Kinds of Microscopical Plants, are much greater in number than many Modern, Very Able Observers have believed, among whom merits distinct mention the Very Famous M. *De Buffon*.[257]

The slowness with the which up to now, since the beginning of February 1766, this printing has been conducted, has increased for me in the meantime toil of adding more things, that at first were not thought of, and has obliged me to divide the Work in two Volumes, namely into that which contains the five theoretical Parts, and to reserve for the second all the remainder, that comprise the practical rules, for the purpose of relieving the Poor, in calamitous times of the Dearth, which in this interval of time, go from me increased, and as much as possible not ably improved, with the end of compensating by greater utility to the Public, the prolongation of the edition.

THE END OF THE FIRST VOLUME

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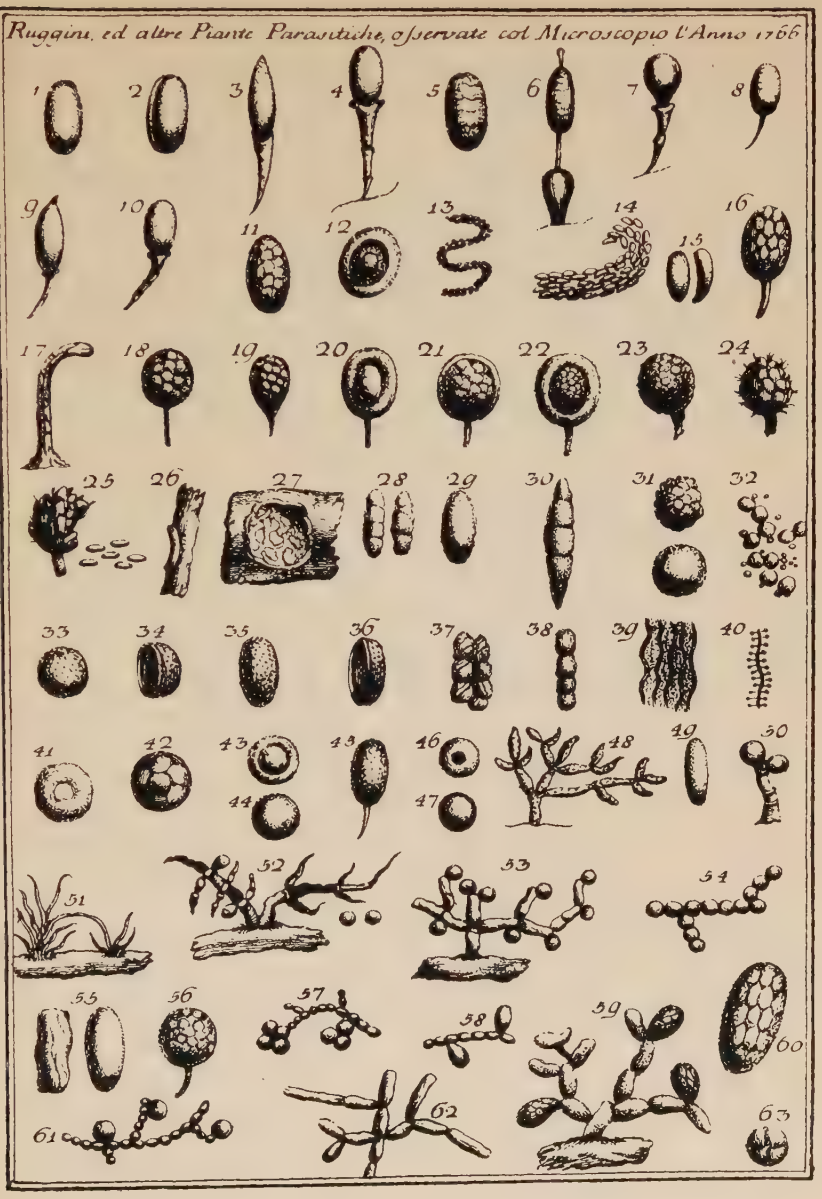
[256] Second Memoire p. 387.

[257] Hist. Nat. T. 2. Par. 2. p. 21.

ADDENDUM

Although the Spring of the current year 1767 may have been dry, and without Dews, yet suddenly after a great Rain, that fell on the day May 3 and was repeated on the day 5, and produced some Fog at the rising of the Sun, there commenced to be seen in the Fields of the Plain a little of the Rust of the first kind, on only the leaves of the Grains which did not advance as a consequence. At the end of May, and in the early days of June there appeared in great supply, only on the internal surface of the Little Chambers of the Grains, whether Large, or Gentile, certain very minute Tufts of a new kind of Rust, round, smaller than the Knobs of Pins, of a gilded very vivid color, not enchased in the membranous substance of the Little Chambers, but only implanted in them. The fruits of this Rust are on the order of Figure 16, but smaller by half, and troubled, like those, by very minute swellings. I have noted that all the Kernels, in the Little Chambers of which the Tufts of this Rust are more abundant, are *imbizzarriti* as the Countrymen say, that is to say they have the eye, or it may be the tail, or the inferior part, or base where the Germ stands, and which is attached to the axis of the Spike, spotted with brown, or black, only on the rind, or bran. This imperfection of the fantastic Kernels, which is not prejudicial to the Vegetation, as I have proved, nor to the Making of Bread, is different from that, which is called *Grano culaccinato,* which is a black spot on the point, or superior part of the Kernel, dependent on the little black fruits of the *Volpe,* remaining attached to the hair, that is on the tip of this point, as I have recognized with the Microscope.


Ruggini, ed altre Piante Parassitiche, osservate col Microscopio l'Anno 1766
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Objects figured by Targioni Tozzetti
as identified by Gabriele Goidànich (1943).

Figure

1. Uredospore of *Puccinia graminis* Eriks. & Henn. (p. 17).
2. Uredospore of *P. graminis,* probably old, in which the author observed a longitudinal trench. (p. 17).
3. Teliospore of *P. graminis* (pp. 17, 19).
4. Another teliospore of *P. graminis* in which are evident the "cornucopia" and the inferior cell (p. 18).
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6. Teliospore of *Phragmidium subcorticum* (Schr.) Wint. (p. 22).
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8. Uredospore of a *Puccinia* inhabiting *Avena sativa* L. (p. 25).
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